Vol. II. No. 2.

THE

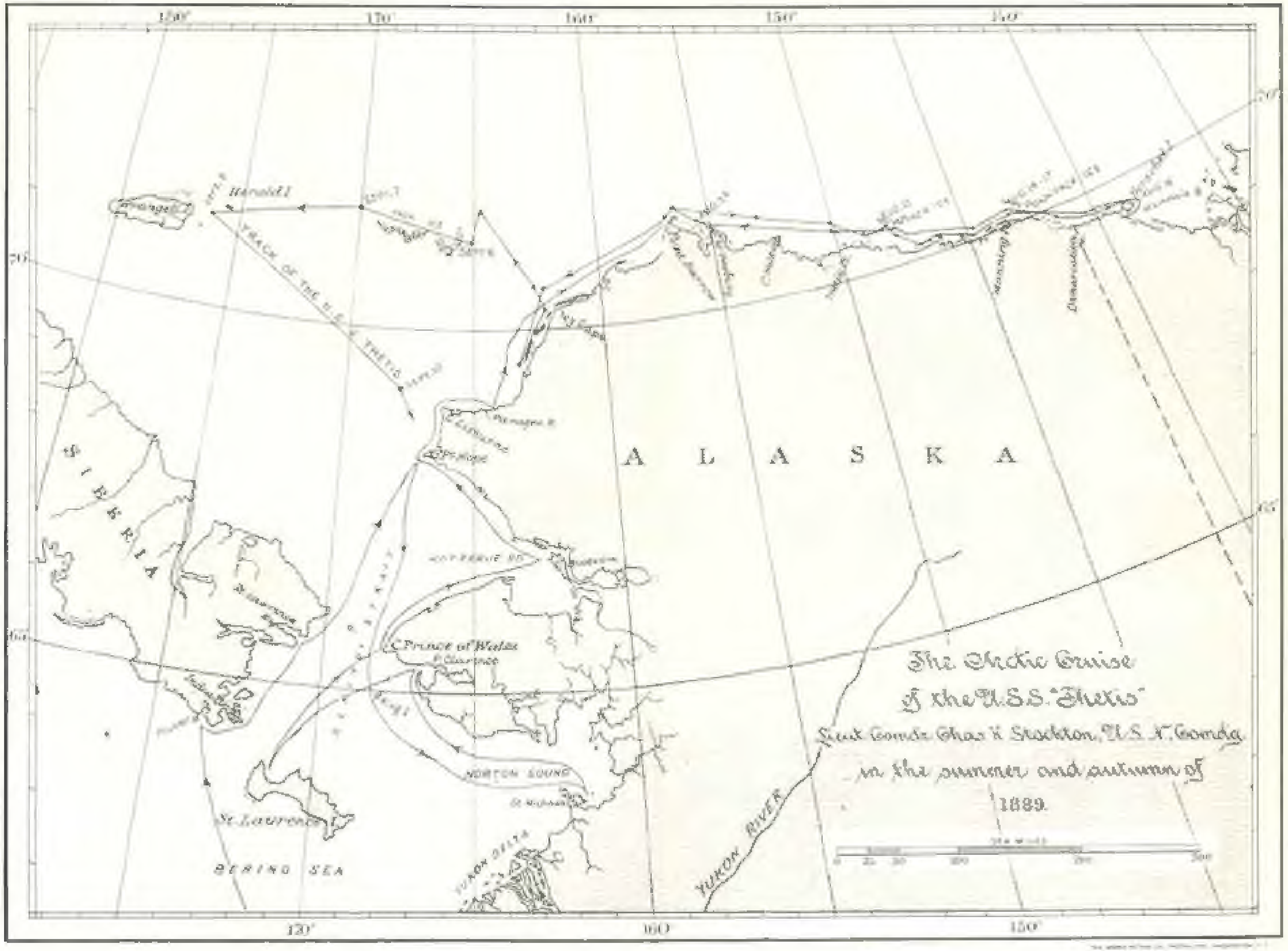
NATIONAL GEOGRAPHIC MAGAZINE.

NATIONAL GEOGRAPHIC SOCIETY,

WASHINGTON, D. C.

Price, 40 cents.

CONTENTS


120°
130°
140°
150°
160°
70°
60°
Herald I
TRACK OF THE U.S.S. THETIS 1889
ALASKA
SIBERIA
BERING SEA
NORTON SOUND
St. Lawrence I.
Prince of Wales C.
YUKON DELTA
YUKON RIVER
The Arctic Cruise
of the U.S.S. "Thetis"
Lieut Comdr Chas H Stockton, U.S.N. Comdg
in the summer and autumn of
1889.

THE

NATIONAL GEOGRAPHIC MAGAZINE.

Vol. II. 1890. No. 3.

THE ARCTIC CRUISE OF THE U. S. S. THETIS IN THE SUMMER AND AUTUMN OF 1889.

By Charles H. Stockton.

A German writer of note once said, in the course of a discussion upon certain French characteristics, that "the trouble with the French people is,—they do not know Geography."

Whether this is still true of the French, as a nation, or whether the authority may be considered a good one, it is not pertinent for me here to say; but I feel that of the nations of the world, this country, above all others (England, perhaps, alone excepted), should not have the want of knowledge of geography classed among its national failings.

We have, however, very much geography yet to learn, as individuals and as a nation; not only of countries beyond our own but particularly of our own continent and our own domain, while commercial geography is almost an unknown and forbidden study.

Professional geographer as I am, as member of the naval service, I find that every cruise adds to my geographic knowledge, and in giving an account of the cruise during last summer of the ship which I had the honor to command, I trust that I may be enabled to present some geographic facts as interesting to my

fellow-members of the Geographic Society as they were novel and instructive to myself.

Before beginning my narrative, however, let me give you an idea of the extent of this shore-line of the territory or semi-colonial provinces along which so much of our cruise was made.

Alaska has an area of about 590,000 square miles, consisting of a large mainland with a coast-line 6,050 miles in length, and also of more than 1,100 islands, with a coast-line of 2,050 miles, the entire coast-line being 9,000 miles. The coast-line of the rest of the United States, including islands, is only 5,550 miles, thus making the coast-line of Alaska 3,050 miles more than the coast-line of all of the rest of the United States.

Of this great country the part known best and visited annually by tourists is that insignificant portion of southeastern Alaska which consists of the Alexander archipelago and its neighboring main coast-line, differing in its scenery, topography, climate, and native inhabitants, from the greater part of this vast territory.

It is fortunate, however, that this corner of Alaska is so easily and comfortably reached by the summer traveler, as, with the exception of the coast-line and inlets between Sitka and Kodiak, which includes the Fairweather ground and the St. Elias range of mountains, this portion contains perhaps the finest and most striking scenery and the largest and grandest glaciers in the territory, if not in all North and South America.

The U. S. S. Thetis was assigned in 1889 to the duty of looking out for the commercial and whaling interests of the United States in Bering sea and the Arctic ocean, to which was subsequently added the duty of assisting in the establishment and erection of a house of refuge in the vicinity of Point Barrow, the most northerly point of our Arctic possessions. The duty assigned to the Thetis did not include the protection of the sealing interests of the United States, nor of those interests enjoyed by the Alaska Commercial Company as the regular lessees from the United States of the Pribyloff group of islands. This was confided to the Revenue Marine Service of the Treasury Department.

The Thetis left San Francisco on the 26th of April, 1889, and after a detention of a month at Tacoma, upon the placid waters of Puget sound, awaiting supplementary orders, reached Port Tongass, in extreme southeastern Alaska, on the 31st of May, and Sitka, the territorial capital, upon the 2d of June. After a stay

of six days at the latter place the vessel left for the island of Unalaska, one of the Aleutian chain, which was safely reached, after a stormy passage, early on the morning of the 17th of June.

The revenue-steamer Richard Rush, commanded by Captain Shepherd, was found at anchor at this place, having arrived a few hours before the Thetis; she had entered upon the duty of patrolling Bering sea, between Unalaska and the Pribyloff group, for the protection of the sealing interests. The seals approach the hauling-out grounds and breeding places upon the islands of St. Paul and St. George in lanes, as it were, from the Pacific, reaching Bering sea by means of the various passages between the Aleutian islands, and converging as they approach the Seal islands, the position of which seems as well known to them. The "marauders," as the men on the sealing schooners are called who hunt them on their way north, shoot them from small boats, killing the many in order to procure the few.

Unalaska, or rather the village and harbor of Illulick, upon the island of Unalaska, is the principal and most frequented harbor in the Aleutian islands, and from its position is a most convenient port for coaling, watering and provisioning en route to the Seal islands, St. Michaels (at the mouth of the Yukon river), the anchorages in and near Behring strait, and the Arctic ocean. This harbor is the headquarters of all of the districts of the Alaska Commercial Company, and is the principal coaling and distributing station and rendezvous of their vessels in Alaska. The company here affords facilities in the way of buoyage, wharfage, etc., which are not only useful to their own vessels but of great service to government and other vessels whose duty or interests call them to these waters.

The revenue steamer Bear was to be met by us at Unalaska, in order that we could take from her any portion of the stores and material to be used in the constructing and provisioning of the house of refuge at Point Barrow that her commanding officer desired to transfer to us.

While awaiting the arrival of the Bear, the Thetis was watered and coaled and prepared for the northerly trip before her. An opportunity offered up by the delay was availed of to inspect the store-houses of the Alaska Commercial Company at this point. The most interesting of the store-houses was that containing the skins and furs collected in the various parts of the

district of which this place was the dépôt. The finest of the furs was that of the sea-otter, probably the most valuable fur in the world, a very superior skin of that animal having been sold at the great fur market in London for £110. Such otters are found in the vicinity of Ounalaska and the outlying rocks and islands as far east as Kodiak, and are becoming more and more difficult to obtain, causing greater risk and hardships every year to the Aleuts, who hunt these animals as a principal means of livelihood.

Besides the otters the storehouse held the furs of the beautiful silver-gray fox, and those of the blue, the cross, and the snowy white Arctic fox. There were also black and brown bear skins, beaver, and fur-seal, the latter, though the greatest and most profitable source of revenue to the Company, being by no manner of means among the more valuable of the raw furs.

To exchange for furs collected, either directly by natives or by independent traders, the Alaska Commercial Company has a large assortment of stores, provisions, and goods, worthy of a large country store, or a Macy's in miniature, which are sold to the natives for money or in exchange for the furs they bring to the company. And just here can be seen the commercial aspects of civilization; as the natives become used to the luxuries and comforts of a civilized and semi-civilized state of life, their wants and their purchases increase and the securing of one otter-skin will not, as in times past, satisfy their wants or the requirements of their wives and families. Hence they become both greater producers and consumers, more otters are hunted for, and the Company is the gainer.

The houses in which the Aleuts and Creoles reside at Ounalaska were found to be well built of frame, sufficiently large and fairly clean. The old houses of earth and sod standing near by show the great improvement that has been made of late years in the method of living.

Upon the 23d of June the Revenue Steamer Bear came in to the anchorage, and the Thetis and the Bear, once companion ships in the Greely Relief Expedition, met again in the far north.

Upon conference with the commanding officer of the Bear, Captain M. A. Healy, it was found that he did not consider it desirable to break the bulk of his cargo and share the stores for the refuge-station with us; hence, being free to pursue our course, we left on the 24th of June for the island of St. Paul, one of the Seal (or Pribyloff) islands.

We [illegible] after groping around in the heavy and almost constant fog and mist had given up them. During our short stay at St. Paul we were able to see a drove of seals from a rookery and the killing, skinning, and packing, which followed; but what we found to be the most interesting was the visit to the rookeries, both from the inshore sea and from boats along the sea front. The systematic partition of the ground, the formation of the harems, the exclusion of the young males, and the aggressive conduct of the older ones, all proved most interesting and novel. This, however, has been done and so often that I will not here repeat it.

Leaving these islands, so unlike any others in the world, we proceeded to the north and west to St. Mathew Island, a large and uninhabited island in the middle of Behring sea. The object in visiting this island was twofold, the first being to ascertain if there were any shipwrecked persons upon the island, the other being to verify the statement made upon the chart we possessed that the island was infested with polar bears. Upon our arrival and landing upon the island we found plenty of evidences of the presence and haunts of the enormous polar bears. This was ascertained after hunting and tramping about for a few hours by parties of officers and men from the ship, who scoured the eastern part of the country, both upon the land and upon the low tundra, but without success.

St. Mathew island is probably the most central land of the select group which we visited in that part of Behring sea, the one below it to the southward and toward the Aleutians also being made up of mountainous peaks and hills of [illegible]. It is said to be by the natives during seven months of the year, and generally covered with fog during the remaining five months. Winds and rains sweep over it during the summer, the low land being composed of wet, grassy tundra, while the higher elevations are formed of snowy and rugged rock.

A large party of draft natives [illegible] upon the steep shores between the [illegible] and the Yukon river from the mouth of Alaska, there [illegible] to procure [illegible] deposits [illegible].

After leaving St. Mathew island we steered west on the Siberian side of Behring sea, in order to secure the whereabouts of the whaling fleet, and, if possible, to gather some news concerning the fate of the whaling bark "Belvidere," a vessel that had been missing since the previous autumn.

Plover bay, Cape Tchaplin and St. Lawrence bay, upon the Siberian side, were all visited in turn, but without success, and I then determined to pass through Behring strait and enter the Arctic ocean. This was done upon the 3d of July, after a heavy northwester on the morning, followed, later on in the day, by a fog so dense that we passed through the straits without seeing land on either side, or the [illegible] at the mouth.

Entering the Arctic we headed on toward Point Hope, to the northward of which the "Jeanie Allen" had last been seen. On the morning of the 4th of July the land about Point Hope was sighted and soon afterwards we met our first ice, coming out in a low, flat cake from Kotzebue sound, stretching some distance from the shore and slowly passing to the northward and westward with the current.

Starting in on this we with the hope of getting around it to the northward of Point Hope, without success, we returned, and after working through it for several days with very considerable difficulty we finally succeeded in getting clear of the native village at Point Hope, finding there two whalers who had just arrived, and afterwards [illegible] that the bark "Jeanie Allen" had been wrecked [illegible] opposite the point where we were then at anchor. Taking on board, the next day, those survivors of the shipwreck who were remained at the place, we left for St. Lawrence, [illegible] of the Yukon river, there to transfer the survivors to the steamer of the Alaska [illegible] Company and to send the news of this [illegible] to the Navy Department and to the world. In passing through the ice outside of Point Hope the first polar bear of the season was sighted, [illegible] upon a cake of ice. A few shots settled his case and he was fortunately secured, his skin now [illegible] the cabin.

[illegible] way [illegible] [illegible] point [illegible] of a heavy fog, [illegible]

Kowbuck, Noatak we found these two steamers of the Alaska Commercial Company at anchor, besides several river-steamers, and a number [illegible] of natives from the coast, [illegible] from the interior, who [illegible] and [illegible] from the Yukon, —all here to meet their annual mails and supplies. In addition there was a party of government surveyors to determine the boundary-line, an account of whose early journey has been

given to the society by Mr. Russell. There were seventy-three tents, by actual count, pitched about St. Michaels at the time of our stay, the shades of these temporary residents.

St. Michaels is the most northerly settlement and trading post of the Alaska Commercial Company. It is the outlet of the Yukon river trade and is so the source of supplies for the country bordering upon the Yukon and its many tributaries, reaching in this way a portion of the Northwest Territory of the Dominion of Canada, west of the Rocky Mountains.

In the winter-time the post consists of the offices and storehouses of the Alaska Commercial Company, with a few residences for their white employés, and a small native village.

Small, light-draught, stern-wheel steamers ascend the Yukon and its tributaries for a distance of 1,700 miles, reaching the mouth of that river in part by an inland and in part by sixty miles of outside coasting.

After a short stay at St. Michaels we proceeded to Port Clarence, where a large number of the whaling fleet were met consisting of seven steam whalers, six sailing whalers, one trading vessel, and a sailing tender from the tenders these vessels receive coal, provisions, and supplies, sending back to San Francisco the oil and whalebone of the spring catch.

Port Clarence is the best, as it is the first, harbor on the American side before reaching the Arctic, where no harbors exist worthy of the name, west of Norton Sound. There is no native settlement of any size on the bay, but natives assemble here from the surrounding country and barter to trade with the whalemen in season.

Leaving Port Clarence we ran to the westward by Kotzebue Sound to St. Lawrence Island, a remark of a sailing tender that was here overtaken, returning, after a stay off the village near Cape Prince of Wales, we again entered the Arctic ocean. As it was too early to go to Point Barrow we proceeded to Kotzebue Sound until it should open. In the vicinity of the trading place, every year, a number of natives meet for trading purposes, the Eskimos from the Diomedes and Cape Prince of Wales bringing articles of trade from Siberia, while the Eskimos from Point Hope bring articles obtained from the whalers, these Eskimos are met by the Kotzebues from the rivers that flow into Hotham Inlet and Kotzebue Sound, principally from the Kowak, the Noatak and Selawik rivers. The nearest available

anchorage we found was Cape Blossom, from which place we visited the settlements and were visited in turn by the natives. We had now been thirty-six hours or more without sleep, the twenty-four hours' daylight, the two nights we had spent in beating our way to and from Point Hope during our first visit to that place.

Leaving Cape Blossom upon the 24th of July we stood out of Kotzebue sound for two northward, running in the greater part of the time on a canvas fog. We passed Point Hope on the 26th, Cape Lisburne on the 28th, and anchored off Cape Solomon early in the morning of the 29th of July. Near by was a very wide vein of agate coal from which the Tigara had been cutting their year's supply, to which the name of "Tigara coal mine" had been given. This had been worked during the present summer, also, and a party of natives who were encamped near by had furnished considerable of the workers.

Being now in the vicinity of a stream known to the natives as the Kuk river, I went up it a while both to examine its mouth and entrance, as the stream was known to but few whites and did not exist upon any charts or maps. It was found to have but three feet of water on the bar at its entrance, but after crossing this a depth of six feet was found. The stream was found to be full of bars and shoals that we could ascend but a short distance after entering it. The river and its narrow valley were very winding, the general course being north west from its mouth to the coast. After the spring thaws, and the rains that follow, the stream rises to a depth sufficient for the passage of small steam-launches for a distance of almost forty miles. The height is estimated by the oldest inhabitant as ten feet. The river has been explored the previous year by John W. Kelly, who was this summer employed on board the Thetis as official interpreter, and to him I am indebted for the following description of the beautiful scenery upon the banks of the Kuk river, and also of a remarkably hot stone bath near the mouth of one of the tributaries.

[illegible] from the south of the river spurs out to the banks of the river, closing the northeastern valley that stretches away to the sea-coast in an almost unbroken wall of a mile or more from southward, and receives the full benefit of the sun

...ght through the short purple summer. Under favorable circumstances the soil is covered with plants, along with their seeds, upon the surface of the ice to a depth of from four inches to a foot. The new flow of water soon vanishes before the June sun, while the light penetrating above the glacier preserves it intact. Vegetation is warmed into life in a remarkably short time, and the brown pall left by the receding snow is almost instantly transformed to a robe of green, studded here and there with bright polar flowers, these being buttercups, dandelions, yellow poppies, bright saxifrages, gentians, cinquefoils and marguerites. The latter are small and unobtrusive, making a showing in a manner as if they wished to appear grateful to their sister flowers for their appearance among them. Like beautiful evil women girls, one cannot resist a contemptuous and cruel mood of feeling toward them. But these prominent attractive flowers, no matter on the soil upon which they grow, bloom in the polar garden with as much right as the meanest potentilla. Besides all these, there are the hardy grasses whose roots permeate the light coverings of soil to the permafrost, wherever they survive frost to germinate. A few shrubs are to be seen, but they only grow about a foot in height, and trail upon the ground. The Pingasa river is gradually cutting into the glacier, receiving from its [illegible] and leaving a bed of [illegible]. During the summer the ice melts away, leaving the protruding and above it like the eaves of a house, when it protrudes too far for the strength of the crystals, it topples over into the river. At the freezing point in the autumn, another freeze from the overhanging gravel to the river below, forming a narrow [illegible] that [illegible]

On Stone Hut

On the highest peak at the source of Icek creek, a southerly tributary of the Pingasa, are the ruins of a hut and smaller outhouse, the like of which one never has met with in Northwestern Alaska. Above the grass line, past perpetual snow, up where wild storms sweep away the snow, as I said, we were [illegible] by a few gray lichens are to be seen, but at some former time, has played a busy part. On the west of the mountain there is a sheltered interstice of the twelve feet in depth, crevices and shutters into flakes by the vigor of the polar winters. On the south side of this cleft, sheltered from the prevailing north winds, excavations have been made into the rock. Taking the coal of rock

for some mile of the house, the other side of it has been built up with dut stones, laid up like bricks in masonry, but without mortar. Moss and soil have been in the probability used, over a mound of stones, but several of these were to be seen lower down at the entrance. The structure is round in shape, after the manner of a dressing-room at a swimming-bath. The circle is about seven feet in diameter. Having also in remote parts of Alaska come upon similar constructions, and not always used as a sweater for gold-seekers at this have erected houses like unto it, it is so that they were for certain, and I am fully persuaded of it as the natives are partially acquainted with soil. The will be inside but an hundred of age, and I do not believe have ever found who have ever heard of it. From the summit of the peak a splendid view is obtained of the surrounding country, the Arctic ocean, and hills of pure ice in order.

For I have been for the proper the Pingasen, at the head of the same creek and tributary, it being considered to be a place where could in larger quantities in that the city, here being from $4.50 to $6.00 worth of gold to the pan, the country and but unpleasant, however, and the, together with the shortness of the season, would prevent any large profit.

Our party remained from the Pingasen with a few pleasantness and to the a week's delay arrived the ship was at the gutter way and we stood to the westward for Point Barrow. It was certainly pleasant, but fortunately we escaped the fate of the vessels in the fore part of the season.

On the next day we enjoyed a superb Arctic summer day, and began to find us with the whaling fleet on the way to the Point Barrow. Several vessels were sighted and a pleasant part of them vessels under sail. Soon they the danger to be seen a mile and the lee edge of the land ice, we set out to the northeast, finding open clear water, with a westerly drift. Upon the floes we found great quantities of whales, in some cases stretched at full length, some dead and others alive. One large fellow evidently had been harpooned at not approach that he was supposed to be a well armed Irish potato around him so as to slip quickly and off the floe and disappeared beneath the surface.

Freezing as we passed Pt. Belcher at 4.30 in the evening, in the fog and rain, and came to heavy masses of ice over which a new fog had settled. With some delay and difficulty we worked out of both the fog and the ice and at five o'clock in the morning

sighted four vessels—steamers—at anchor off the village of Ootkeavie at Cape Smyth, 8 miles from Point Barrow, and the site of Captain Ray's Signal Service meteorologic station of some years ago, the house built for the party being still standing. One of the steamers proved to be our old friend the "Bear," which had passed to the northward when we had returned southward from the Arctic with the survivors of the "Little Oliver." The other vessels were made out to be steam whalers, and at seven o'clock we anchored near them, off the site determined upon for the house of refuge.

Finding the Bear had commenced to discharge her stores and materials, all of our facilities were at once used in tendering her assistance, our steam launch Achates (now, as of yore, the chief of the Thetis) being busily at work towing boats to and fro, while our men and mechanics, with officers, were busily engaged in aiding the construction of the house of refuge.

Our arrival at Cape Smyth and vicinity of Point Barrow was on the 28th of July, the Bear having arrived on the [illegible] Saturday previous. While we were lying at anchor engaged in the erection of the house of refuge, the rest of the whaling fleet, both sail and steam, gradually arrived and came to anchor off the coast, reaching from Cape Smyth to Point Barrow. After a short stay the steamers went on to the eastward of Point Barrow, following along the ice-pack, which was in sight from Point Barrow, until they reached the heavy ice off Point Tangent. When the last of the whaling vessels had arrived, a fleet of forty-seven vessels carrying the American flag had assembled within sight of the most northerly point of the United States, composed of steamers, barks, brigantines and schooners. These vessels, manned by about twelve hundred men, I venture to say formed the largest assemblage of vessels and men under the American flag to be found anywhere during that year. I cannot speak too highly of the skill, seamanship, courage, and endurance of the whaling masters. They are a fine body of American s[illegible]

[illegible] shore was one of phenomenal activity for that region, the erection of the house of refuge, the busy landing [illegible] transportation of stores (in which our men were assisted), the [illegible] of the Eskimos about their village (which was dotted with the white summer tents of the residents and the visiting inland Eskimos), and the clustering and trading about the Whaling

[illegible] a station [illegible] and [illegible] gave a life and [illegible] wind was [illegible] the season. Fortunately the weather [illegible] be [illegible] the storm were heard, the wind then freshened, it came [illegible] could all be kept up and [illegible] of events [illegible]

The site of the house of refuge is within a few hundred yards of Reef's end, and near it stands the village, and the keeper, Captain Bertram (usually known by the [illegible] and Lonely) was busy all [illegible] before the gale came on. During our stay at this place we were [illegible] to make a hydrographic survey of the anchorage, which demonstrated that the contour of the bottom is constantly changed by the [illegible] and planing done by the heavy sea generated and driven up by the pressure of the night by the [illegible] under the influence of northerly winds and gales.

And here let me say a word about the ice of this part of the Arctic ocean. The ice [illegible] consists of floes and fields of various sizes, which are cemented together in winter by the young [illegible] frozen ice. No [illegible] ground in this part of the Arctic, as there are no glaciers near the sea coast to form them. The shore along the entire Arctic coast of Alaska shows evidence of former glacial action, but the only glaciers to be found are in the southeastern part of the territory.

The Arctic pack, which never melts, consists of hard blue ice, made up of floes and fields of comparatively level ice, which are [illegible] and interspersed with hummocks varying from ten to forty feet in height. These hummocks are formed by the breaking and [illegible] ice [illegible] for the collision and grinding together of heavy ice-floes, the hummocks being often [illegible] and [illegible] by heavy falls of snow.

In the spring, under the influence of the prevailing southerly winds and southerly currents, the packs break off from the shore and move to the north, the points of the western edge varying in direction with the season and the winds.

The channel, which remains first to the east and then after the pack moves off, gradually breaks up as the season advances, and, becoming scattered, is taken to the northeastward from the vicinity of Point Barrow and northwestward from the vicinity of Icy Cape and Wainwright Inlet.

Sometimes a long line of heavy floe-ice from the pack grounds in the shallow water near the shore during northerly winds,

present from Ireland by the force and weight of the entire northern pack. It is gradually forced up, pushing its way through the bottom, at the same time creeping gradually along the shore of the bottom toward the land. The effect of this action with cold and relentless blows is shown by ridges and hummocks thrown irregularly between them and the shore, and by the way in which the ice is crushed.

The normal current running north through Dease Strait forms a short distance to the westward of Point Ogle. From Point Ogle to Point Hope, and by capes to Point Barrow, at which point it passes off to the northward and westward, another branch to the west, westward along the Siberian coast, and thence to the northward toward Herald Island. The waters burned by the Corwin were found in the vicinity of Herald Island.

The many portions of the whalers at this time are truly crushing and gone to the eastward of Point Barrow. The last day a communication was received from the Mackenzie River in a whale boat, and reported the ice conditions as nearly favorable as far east as Mackenzie Bay, in the vicinity of which he had wintered. He was a seaman by occupation, belonging to the whaling steamer Belvedere, which had been reported to me by a missionary I met at St. Michaels as having visited the station at Kingmart Harbor, upon the Liverpool River, a branch of the Mackenzie.

Upon the 8th of August the boat of refuge was virtually finished, and as many officers were to be sent by land to the whaling fleet, after the consummation of the struggle I concluded to cruise offshore with the vessel to the eastward of Point Barrow, hoping to run into open water by the mouth of the Colville River and Point Barrow. As I wished to be associated with the Eskimos again, I took Ipsuk and Lee Whale, boat and whaling outfit on board, from the Cape Smythe station, and the evening of the 8th. The sun set right at the time was cold and unpleasant, but pleasant, and evening it almost into a dead calm we slowly stood on a course parallel to the land. We were occupied in working through the ice all night and all of the next day; it was not the pack ice but the ice that had broken off from the vicinity of Point Tangent, Harrison Bay, and Harrison Bay. At times we found it so closely packed together by current and wind that we had to turn back and work our way down again. Three vessels under sail were sighted

The steamer was found to be the whaler Balaena, commanded by Captain Brooks, and the island, though nameless, was marked by a wooden cross, from which fact it was called Cross Island. Captain Brooks stated that he had been struggling with the ice to the eastward of Cross Island, the day before, in company with some other steam-whalers who had left him and gone to the eastward, while he had turned back and anchored off Cross Island. I [illegible] the vicinity of the island, finding good water to the southward, but shoal [illegible] the Thetis to anchor in, and so I remained upon the west side. The wind shifting, our position became insecure on account of the masses of ice drifting toward us; the whaler left the anchorage, steamed out into the heavy ice, and made fast to a high hummocky floe. Seeing no good place near by, I held on with the chain on the steam windlass, ready to heave in a moment. Heavy ice coming down and grounding close by on both sides, we left the anchorage at the [illegible] here to a heavy floe, where we rode out the gale until early in the morning, when we were obliged to move on, as the ice packed about our rudder. After moving again and again the wind fell away, the day cleared up, and the ice began to scatter and disappear around the island, the leads to the eastward looking more promising.

The next day at 3 in the morning, in company with the whaling friend, we left the [illegible] the ice, steamed toward the north[illegible] and larger as we progressed and [illegible] leads more confused until at 10 o'clock the lead stopped and we both made fast to a very large, high, hummocky floe, at least ten miles in length, several miles in breadth, and aground in 80 feet of water. [illegible] and clear, and after [illegible] and the [illegible] over the bows, a number of the officers and men went on the ice [illegible] playing football and snow-balling, while [illegible]. This is the time that we were reported by a steam-whaler that we had passed as being in a position of extreme danger, and the news was taken to the outside world.

About 4 o'clock in the afternoon we started ahead with the Balaena, the Thetis, now taking the lead, [illegible] her way through some pack ice and reached [illegible] going ashore, the Balaena following very slowly after us. We continued forcing our way until we got into clear water by Lion reef. At midnight we made fast to a good floe and, after an anxious night (caused by ice-floes

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Early the next morning, August 14th, at 5 o'clock, we pushed on in company with the Jeanie, starting out of Camden bay and delaying a short time off Barter island to communicate with the natives. At noon, when off Manning point, the smoke of several steamers was seen to the eastward, and when they had come up we found that it was two of the steam-whalers that had gone east. They were led by the steamer William Lewis, commanded by Captain Albert Sherman, probably the oldest and most active of the Arctic whalers. They were all to the east of the Thetis a short time, and I found that they had reached Mackenzie bay at the vicinity of the Mackenzie river. The two missing ones, the Grampus and Thrasher, had last been seen in the vicinity of Herschel island. The ice conditions were reported to be better than those we had passed through. After reflection I considered it my duty, as it was my desire, to go on to the eastward to ascertain the cause of the detention of the two missing wh[illegible] was precious I determined to run on day and night. [illegible] night had assumed the conditions of twilight, and the stars had begun to appear in the skies. The threatening appearance of the weather detained us at first, but at 9 o'clock in the evening we got under way, and with her colors hoisted the good ship started again on her easterly course, followed in about half an hour by our old friend and companion, the Jeanie. Before leaving we had hoisted out the whale-boat with Joe and native friends, who had been joined at this point by the women of the fam[illegible]. Joe was uncertain about his movements here, and as he [illegible] exciting stories from some of the whalers I left him in their company.

We found the shore bolder as we progressed, and the mountains nearer the coast; as a result, the ice generally sets directly and in heavy masses on the shore without grounding, and this point has never been passed before by the whalers, but fortunately a wide lane was open. The sight of the mountains, standing in their grand and gloomy grandeur, was peculiarly impressive, and our inability to make a closer [illegible] exploration is to be regretted. So far as I can [illegible] white man has ever penetrated these mountainous regions, which are known upon the [illegible] Romanzoff, British, R[illegible] mountains, being so named by Sir John Franklin during his boat journey along the coast. The British mountains are at the extreme northwestern

[illegible]

We looked with concern to the sea which stretched, apparently, to the north, and knew that a storm or steward was brewing.

After one of the steerage hands cut first and swept we reached the northeast side of Nantucket and found the two vessels that we were in search of. Captain Hawkes gave a hearty and joyful cry of relief, when the vessels were seen and we were all pleased to see them safe and secure. We came to anchor close by them and the two ship-masters were soon aboard. They reported that they had remained here a week for the return of Winslow from the northward, but as far without any success. They had determined to remain until September, and ordered provisions [illegible] ship with the greatest expedition. They said that a week before that a vessel, the sight of which [illegible] "Enterprise" and "Intrepid" under the command of Captain Hull, with [illegible]

She was a fine vessel, [illegible] and [illegible] following morning were dispatched [illegible] to procure provisions for the squadron [illegible] the vessels

A small, sandy island was found on a northwesterly [illegible] about eight miles distant from the Piankatank river. It would [illegible] a fairly good place for some of the ships to careen [illegible] year for use as watering [illegible]

The water between these islands and the mainland was [illegible] and [illegible] large vessels [illegible] a convenient [illegible] shoals of three feet were found, and [illegible] small

While the [illegible] were at [illegible] and [illegible] the [illegible] to the [illegible] and the [illegible] of the Piankatank, [illegible] the [illegible] and [illegible] the [illegible] and [illegible] the [illegible] the [illegible] and [illegible] the [illegible] of the [illegible]

of many an iceberg, faced once more the icy sea that lay before us toward Point Barrow and to westward.

The weather, however, was superb, clear, cool, and sunny, during [illegible], while in the now darkening shades of the evening for the [illegible] the moon appeared, silvering most beautifully the [illegible] of mountains along the coast and the fantastic shapes of the grounded ice.

On the 17th we began to meet and overtake the whalers who still delayed in the vicinity of Camden bay, waiting for whales. Five were passed, some cruising and some fast to the ice-floes. After communicating with them and informing them of our probable movements, we kept on to the westward. The ice conditions were favorable and we made very good headway, making fast to the ice-floe, off one of the small islands of the Midway group, on the evening of the 17th of August.

The wind is always a subject of constant watchfulness and anxiety in this part of the Arctic. It not only makes the currents and brings down the ice, or sets it off and clears a narrow lane along the shore-line. A northerly slant of wind created a desire to push on, and passing the [illegible] we sailed Return reef again and skirted along the long and narrow island which now bears the name of the Thetis. Passing the [illegible] of the [illegible] we steamed at a good rate of speed through Harrison bay, and there the wind blowing strong from the west, bringing [illegible] with it and accompanied by a cold fog. The outlook being discouraging I determined to press on for Point Barrow, not very far distant. The early morning of the 19th of August opened heavily overcast, and [illegible] with a gale from the westward, [illegible] increasing in amount of sea.

There being no protection from the wind this side of Point Barrow, I desired full speed so as to get to the point and beyond it before the [illegible] shift to the eastward, which would bring the ice down and shut us out. The leads between the floes became narrower and fewer in number, so that the better outlook was [illegible] as we edged the shore as far as the shoal water would allow us to go. At this time we sighted as many as eight polar bears on the ice, but this was no time to hunt "game" [illegible] of our [illegible] we steamed through the pack and [illegible] however [illegible] into water too shoal for us. Finding from my perch aloft that the ice seemed even heavier to the west, I determined to stand back to the eastward into the

[illegible] upon water we will [illegible] by the land we had [illegible] now that [illegible] but it was too late; the lead had ceased and we were powerless in the pack. There being no other place to go, I reluctantly selected the largest pan, or pocket, got out a pneumatic, and made fast to a large floe, a mile and a quarter [illegible]. It was found to be so slow in motion, and [illegible] four times during the night we had to move to avoid the heavy floes closing in around us. [illegible] were close pressures in the heavy pack which had set in with the wind, now northerly, between Point Barrow and Point Tangent.

In the words of the Ancient Mariner of Coleridge:

> "The ice was here, the ice was there,
> The ice was all around:
> It cracked and growled, and roared and howled,
> Like noises in a swound."

By constant watchfulness, almost of instant movement, a [illegible] warning, faithful working of the engines, and [illegible] of [illegible] a favorable shift of wind, two good ships, under Divine Providence, escaped without damage or detriment from nearly within easy reach of land was, but twenty-five miles from Point Barrow, I had no means [illegible] for, but I have no doubt in my mind that the [illegible], or [illegible], and whose return of the officers and men of the whaler [illegible] bringing out of the ship [illegible] from the pack, after nearly five days' imprisonment, at the time of great [illegible] from the proper [illegible] and [illegible] their continuing [illegible] on the present [illegible] of the high appreciation of their [illegible] and [illegible] where we [illegible] them.

[illegible] of the 28th of August, after a night of hard [illegible] things, we anchored off the west side of Point Barrow, [illegible] by natives from the whaler [illegible] there and by the hearty [illegible] of the [illegible], who were [illegible] on board of [illegible] and began [illegible].

[illegible] these boats at the ice [illegible] down on Point Barrow and Cape Smyth for several days, during our absence. The few women that remained [illegible] were unable, of course, to afford us any assistance, which [illegible] having to work out her own salvation [illegible] was a day of great service only in [illegible]

of damage or abandonment. Fortunately, the storm whalers remaining behind us did not have the pack set down upon them in the shallow bight in which they were cruising, and the ship continued north easter which aided us in our escape enabled us to find leads to get through, not very long after we had escaped. We remained at Point Barrow for a week or ten days and all returned, except the two most easterly ones, left at Herschel Island. As their return was so uncertain, at the end of a week I dropped down to the house of refuge at Cape Smyth, and by previous arrangement with the authority at that station, went to the westward, first going to Icy Cape to erect a needle beacon as a warning of the vicinity of Blossom shoals.

Leaving this vicinity on the 4th of September for the northward and westward, on a rambling cruise among the ice, we stood to the north, reaching the supposed vicinity of the edge of the ice pack that night. As the nights were now dark we lay-to until morning, when the rapid fall of the temperature of the water and the freshening wind gave indications of its proximity, and a half hour's steaming brought us to the expected intersection of the pack. Along this we shaped, having regard to our [illegible] north (true) [illegible] N. latitude.

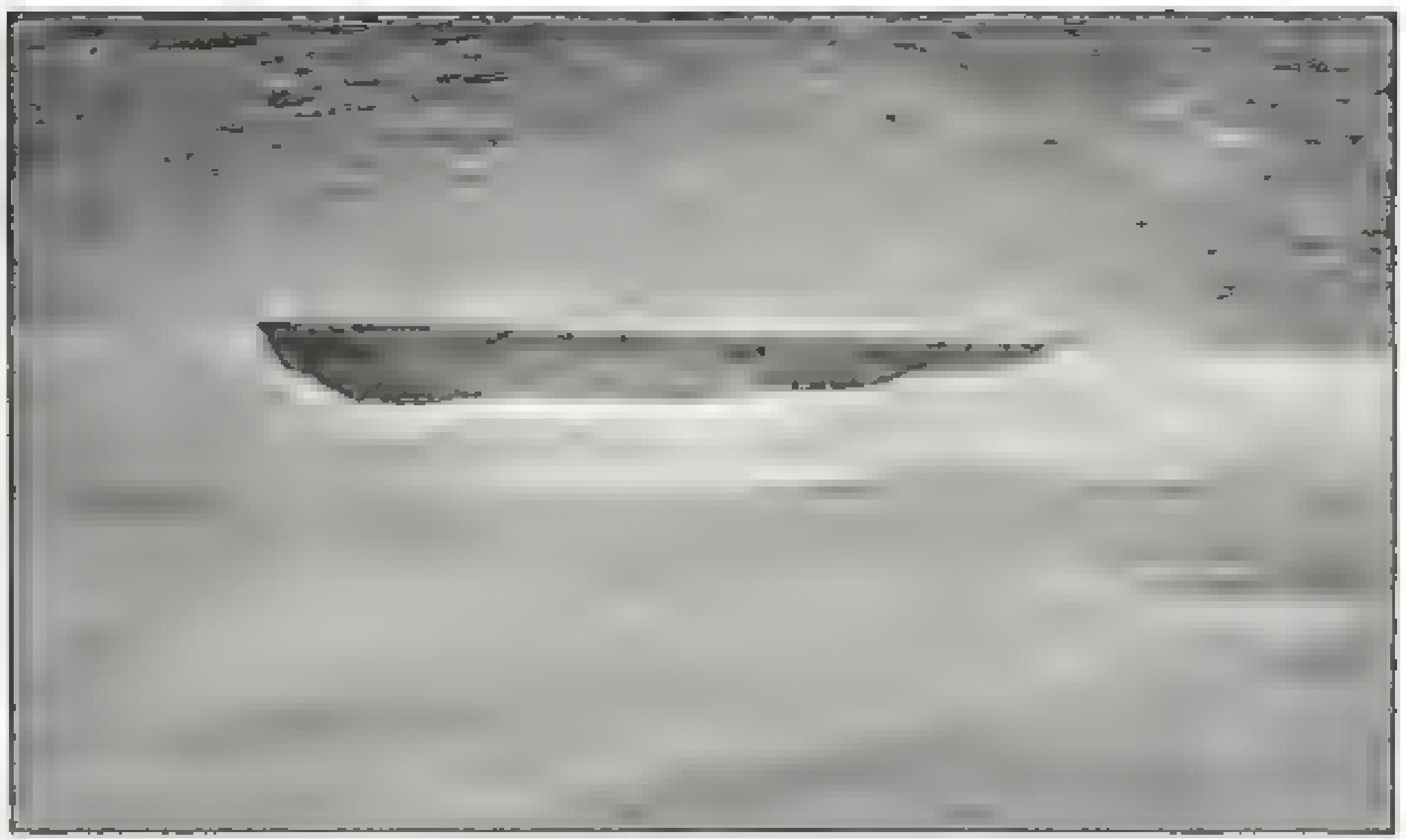
All of that day and the next we continued our course, sighting a portion of the outlying fleet of whalers on the 7th. Communicating with them of our proposed movements and whereabouts during the rest of September and the first week of October, we then stood to the westward. I must not forget to mention an interesting one-act that occurred. A schooner stood down to us from the fleet, and was recognized as the well-known Jane Grey, packed up by the Siberian whale under the command of my predecessor. As previous sent her in the pre-arranged. She had been refitted, painted out, repaired, and restored to her owner, who had literally sold his farm and put cash into the vessel. As he came within hail our interpreter was given him, but I noticed that he fairly danced with impatience during the delivery, which was necessitated for the benefit of the message by his bringing out his own, who were stationed behind the foresail, a strong bounty and prolonged cheers for the Thetis which fairly rang out in the silent Arctic air. To this we responded and then went on our way.

We now left the pack and stood through open water for Herald Island, which we sighted at half past twelve the next day,

the 8th of September; as we approached it nearly the lowness and forbidding appearance, which had been concealed at first sight by the brilliant luminosity of the atmosphere, became very marked. Its sides were almost inaccessible, except from the western end, and it was free from ice, an almost exceptional state of affairs. In close proximity it is impossible to reach it, and, even more than Point Barrow, it may be said to be the work by one that refuses to receive darkness to the shore.

We passed it late in the afternoon within a comparatively short distance, standing on to the west with the hope of seeing Wrangel land before dark. At last just five land was reported ahead from afar, and soon the high snowy peaks and mountainous outline of Wrangel land was located from deck. It stood out beautifully in the late Arctic afternoon, and as we approached it more closely its outline became more and more distinct and bold. At sunset we were about ten miles distant, and at dark, as we turned to the south-east for Point Hope, we exchanged hearty cheers at the prospect of our coastal passage from Herschel Bay to Wrangel land. Arriving at Point Hope upon the evening of the 11th of September, we found that many of the native families had returned from the interior, and preparations were going on for the winter season.

The natives of Point Hope, like the Eskimo generally of northwestern Alaska, have no recognized form of government except what exists by control of the head man, or chief, whose supremacy arises from his wealth and influence. The present chief and only white man has a terror to the community. His rule was by force, and by the influence of the rifle, which was his constant companion. After a career of assassination, murder and robbery, he had come to a timely end by being assassinated by the brother of a wife he was torturing to death. Since his death, up to the time of our visiting it, no violence, murder and personal different treatment received by the survivors of the wrecked whaler "Bowhead" from the Eskimos at Point Hope to a proper nature, I determined to appoint a head man or chief who would be charged with the responsibility and duty of caring for any shipwrecked persons or distressed whalers. Accordingly, I was appointed by me and whose appointment was afterwards confirmed by the governor of Alaska, has inherited the office of the previous chief, and was the best whaleman and hunter of



the district. He had been in the employ of the whaling station established this year at Point Hope, and had been satisfactory in all his dealings with the whites. His wife was a very superior woman, and their desire for civilized dress was so great that a bread-pan of tin, some grease-ware bowls, and candles, were given and eagerly accepted as contributing to make their dreary lives more comfortable and civilized. An urgent request was made for a cooking-stove, which I promised to give them if I should return the following summer.

The Eskimo lamp which serves as a light, and to some extent as a stove, is a crescent-shaped stone dish with a shallow trough scooped out; this is a receptacle for the blubber, the wick being made of moss laid along the edge of the lamp and trimmed from time to time, the supply of oil being kept up by a lump of blubber suspended over the lamp. The light using indifferent candles are welcomed as a great improvement and a marked relief to the sore-lidded eyes of the men and women during the long nights of the Arctic winter.

During our stay at Point Hope we found much of interest in connection with the Eskimo village. Their long winters give them an opportunity to keep alive their traditions in their quarterly meetings in the communal house, and they give an account of their early days in this way. In the beginning the people were Loucheux, or ravens, with eyes on the upper part of their breasts. All was water at this time save a single spot of dry land, with no change of day and night. At that time there lived a powerful chieftain on a top of the highest peak. In his house were two lakes that were enclosed very precious and were therefore carefully guarded. One day, the chief being absent and the guards asleep, some children who had long admired the beautiful lakes knocked them down with a stick and they rolled across the floor of the hut and down the side of the mountain. The noise awakened the guards, who turned after them, while their extraordinary beauty attracted the attention of the people, who also rushed after them, a wild struggle ensuing for their possession, just ended at the breaking of the lakes. Light sprang from one and darkness from the other; these spirits of light and darkness claimed sole dominion, neither yielding, a compromise was made by which they agreed to an alternate rule. The violent struggle for the mastery so disturbed the world and the economy of the people and the surface of the

earth were both changed. Light broke upon the earth, men began to catch whales in the sea and to carry the flesh and bones to their native homes. One family was living over the country recently risen from the sea where now stands Point Hope. Large vegetation sprang up and whales abundant, they built a hut and made it their home. From it originated the settlement at Point Hope. Their modern history goes on in this wise: Point Hope being favorably situated for whaling and hunting the walrus and for obtaining the reindeer it naturally became a center of power and population. In the latter part of the eighteenth century, as well as can be determined, the village on Point Hope, known by the natives as Tigara, had a population of 1,000 souls, with six communal dens. At that time the Eskimos residing upon the North, or Inland river, began to encroach upon the territory of the Tigaramutes.

In matters came to a head that about the beginning of the century a great battle and total fight took place between the Tigaramutes and the Nunatalmiutes near Cape Seppings, in which the Tigaramutes were defeated and forced to yield a large portion of the territory formerly controlled by them. So

[illegible] were the Tigaramutes that they cut one-half of the population, which left in the [illegible] standing at open. Since this time the population has gradually increased, the growth is in large measure [illegible] by the fact that two, who are perpetually represented here by the [illegible] of the walrus skin, [illegible] during the year a number

[illegible] are short as measured at least [illegible] feet [illegible] seams, and of ten women, 5 feet 2 inches. The legs are short as compared to the length of the body and are always much bowed, this being due to the manner in which they are carried in infancy upon their mother's back, the legs being brought tightly around [illegible] the most [illegible] parts. [illegible] and hands of the women are generally well [illegible] small

All of the [illegible] have good teeth, but as they are used [illegible] even deeply they [illegible] in every way. They are used as [illegible] for [illegible], carpenter's vises, and during machines. They are used as drawing [illegible], [illegible] being the [illegible] end of a cord, [illegible] bird-skins, and stretching skins. When they [illegible] as even front [illegible] this way, the uneven [illegible] is corrected by a level lay down by [illegible] of [illegible]

[illegible] stage, until they finally reach a level too low for mechanical purposes.

Between sixteen and twenty-two years of age the male natives have their lips pierced under each corner of the mouth for labrets.* The incision is made and at first sharp-pointed pieces of ivory are put in; when the wound heals the hole is gradually stretched by inserting larger labrets until it has attained [illegible]. The poorer natives wear labrets made of [illegible] common gravel, and glass stoppers which they obtain from ships and adapt to this use. The stopper of a Worcestershire sauce bottle is very useful for the purpose. The richer ones have agate labrets, the most valued one, however, [illegible] center of [illegible] stones, nearly an inch wide, fastened with a spruce gum on [illegible] from the interior. We could not ascertain where the turquoise or pieces of like stone was obtained. The Eskimos say they [illegible] always been in the country, and set the [illegible] with the greatest [illegible].

Tattooing is general among the women, and is apparently a custom of great antiquity. At the age of six one narrow [illegible] is drawn down the center of the chin from the lower lip downward, powdered charcoal being used as coloring matter. At twelve years the line is broadened by additional ones, and a narrow one made parallel to it on each side. But I must not detain you by giving other particulars.

On the [illegible]th of September the Thetis left Point Hope for the south, the roughest season of the Arctic seas having fully set in. Strong winds and gales from the northeast had compelled us to move from the northern to the southern side of Point Hope, where better protection and anchorage had been found. On the 21st of September we passed out of the Arctic ocean and through Bering Strait, reaching Ounalaska again on the 28th of September. After remaining there until the beginning of October the ship returned to Sitka, and after a prolonged stay in the waters of southeastern Alaska we finally reached the Golden gate of San Francisco, shortly after midnight on the 5th of December.

* *Labrets* is the name used along the coast for the lip-ornaments worn by the natives.

The cruise of the Nome was remarkable in several respects, among others in that, thanks to the open season, her stanch build and successful battling with the ice-pack, she was enabled to reach Mackenzie bay, in British North America, the first government vessel to carry the American flag in those waters. She also made the long stretch from Mackenzie bay to Herald Island and Wrangel land in one season, never before done, and she had the honor of being the first vessel of any kind to follow the entire main coast line of Alaska from Port Tongass, in extreme southeastern Alaska, to Point Barrow, the most northern point in the Arctic ocean.

THE LAW OF STORMS,

CONSIDERED WITH SPECIAL REFERENCE TO THE NORTH ATLANTIC.

By Everett Hayden

Abstract of a paper read before the National Geographic Society, Nov. 15, 1895

In preparing an abstract of this paper it is found very difficult to adhere very closely to the original, inasmuch as that was illustrated by forty-five lantern slides, which it is only practical to present a few plates with this abstract. I may therefore be permitted to give only a general outline of the subject, with perhaps a more detailed discussion of one or two of the most notable recent hurricanes off our Atlantic coast.

The term "Law of Storms" is applied to the knowledge of rules that shall govern the action of the master of a vessel, when he is [illegible] like the cable tow, is somewhat vague. So many considerations enter as factors in the question that it is wholly impossible to lay down any rules that shall be applicable alike to a well-powered, well-manned steamship, and to a heavily-laden, poorly-equipped sailing vessel. Disregarding such differences of conditions (which are, of course, of vital importance in each individual case, but which cannot be discussed in a brief general essay), the two grand divisions of the subject may be compared to *ground strategy* and *field tactics*. By this I mean that a broad, comprehensive view of the whole subject of ocean storms—their origin, seasons, size, severity, and tracks—is the very important part of the navigator's duty at [illegible] like a plan of campaign; while, secondly, the handling of his vessel when actually in the fight—the cool-headedness, clear-headedness, and practical experience that utilizes every resource of the best seamanship and intelligence in a fearful struggle with the fury of a hurricane—all of these are also an essential part of the education of the true sea-captain.

Thanks to the progress of meteorologic research it is comparatively easy nowadays for anyone to get a very good general idea

[illegible]

officers even on board naval vessels; they find at that time sufficient data not to enunciate criteria but to excogitate them and sooner or later they get out of the habit of writing up the actions taken to avoid a storm or manœuvre in one, just known up at the time when a competent man had to the actions that were taken, and not always having anything brought forcibly to their attention to indicate with certainty whether the person was well-advised or ill-advised. Upon finally attaining command themselves they are not, therefore, as well posted as they might otherwise have been. I must attribute things to explain the undoubted fact that comparatively few masters of vessels are well posted in certain very important matters to the real law of storms, as it was discovered by Redfield and enforced by Reid, Piddington, Thom, and other early writers. In fact, of all the navigators of various nationalities who have charge to-day of the commerce of the world, probably four-fifths are wholly ignorant of the progress that has been made in this direction in the past fifty years. That such is the case is not, in my opinion, wholly their fault; it is owing to the fact that far too little attention has been paid to clear, forcible, and convincing explanations; it is the fault of the teachers, no less than the scholars,—of the men in boards who take over the results of their researches, instead of stating facts and conclusions in a way to command attention and respect from the practical men who furnish the data, and who deserve some tangible results in return for the long years of voluntary observation.

It is well for us to put this matter very [illegible] apart from and with the conduct we must observe in the management of a vessel in such, and I shall only attempt to do so in a very general way. It should be understood, first of all, that a hurricane is an enterprise which is, as a rule, in fact, that is a regular nature was generally recognized only about fifty years ago. At the immediate center of the whirl there is a clear space, from five or ten to forty or forty miles in diameter, generally with blue sky and bright sunshine. Within a short distance of this central calm the wind blows with frightful violence, and here a vessel is [illegible] even along in about the [illegible] encircled in midnight darkness, buried in a fly ing mass of foam and spray, with every [illegible] one of the elements. The edge of the hurricane, as this region has been called, is small, relatively to the entire area, and it is there that a few miles may make all the difference between a sperry k and safety. The que-

tion is, then, to avoid getting into the core, or heart, of the hurricane. It is evident enough that if the wind blow in a strictly

[illegible]

circular direction around the center, the bearing or direction of the center must be at exactly right angles (eight points) to the right (or left) of the direction of the wind. In the Northern Hemisphere (where the direction of rotation is against the hands of a watch) the center bears eight points to the right of the wind, that is, to the right of the direction from which the wind blows. [illegible] of a hurricane off our coast, for instance, if the wind be NE. at Hatteras the center would bear (according to the eight-point rule) SE. Considering, further, that the center which has a progressive motion along a path, [illegible] of an observer at Hatteras find the NE. wind freshening rapidly, without any shift or change of direction, it is equally evident that the center of the storm is approaching directly toward that point. In a similar situation at sea, a shipmaster would naturally see that his vessel was in a position of great danger; evidently the best thing to do would be to run before the wind, thus getting out of the way of the approaching hurricane. This simple case will explain pretty clearly, I think, how rules were at once formulated [illegible] as Redfield had proven [illegible]

Without going further into this subject, inasmuch as [illegible] point rule is perhaps the most important of all the rules—indeed all of them follow directly from it [illegible] that subsequent re-

search, based upon careful observation and the accurate charting of hundreds of reports from vessels in similar storms in various oceans, proved conclusively that the wind in a hurricane does not blow in strictly circular whirls, but rather spirals inward, so that with a NE. wind off Hatteras the center bears probably S. or SE., or even South; evidently this is a matter of vital importance to [illegible] and the ship should be removed to get [illegible] Sailing, indeed, actually the fact, and in no case nothing could be worse than to run directly before the wind; at any event it would be dangerous, and in the case of a slow moving cyclone it might really lead the vessel directly into the core of the hurricane. This is known to have been the case in many instances, and vessels have been thus drawn into the innermost whirls of destruction and kept there for several hours, making one or more complete revolutions around the center before they could extricate themselves. In fact, they might never have gotten out, if the storm itself had not moved off and left them.

The first of the above papers [illegible] entitled

"Storms,"

gives a brief and yet complete resume of what is perhaps the best modern practice. In these brief statements the attempt has been made to put concisely, and *completely* for one who but read each and every word as carefully as they were written, the very most important, and best-established facts, with which every navigator should be familiar. The "shalls and shall nots" [illegible] "should and but," for instance, is very important. A close consideration of the author's expressions in these few lines may reveal a serious mistake to all might be made by a too rigid adherence to the old rules. The rule is as follows: It has been proved by Mr. Dove, from his studies of [illegible] hurricanes, that in the Atlantic trade winds [illegible] of a hurricane rather than at right angles to [illegible] the direction of the center, and it is therefore always to be approached generally toward [illegible] This may be true, but may be exceptional [illegible] If a vessel starting in a deep recurving [illegible] Abaco, or a discharging ship of

the whole subject, has shown that such is the case, although he states that "the [illegible] of this belt [of intensified trades] dif[illegible], so that a special set of rules are [illegible]y for each country." It seems to me, I must say, that in the absence of such special rules the law may safely be assumed to be general, its importance to navigators is certainly very great, and its principal effect must be to urge the greatest caution in making any attempt to cross the track of a hurricane, from the dangerous to the navigable semicircle.

The next plate,

THE HURRICANE OF NOVEMBER 25, 1888,

is a very instructive illustration of an actual hurricane, and one of the most severe on record off our Atlantic coast. The spiral lines have been added to bring out more clearly the wind-circulation, and several features will at once attract attention: the elongated shape of the storm, along a north and south line (the direction of motion), the wide region where there is a northeasterly gale (exactly analogous to the belt of intensified trades); the long sweep of northeasterly winds along the coast; and the marked variation from a strictly circular wind. The right-hand side is the dangerous semicircle, and it is here that the navigator is called upon to decide whether he shall dare stand the attempt to run before the wind and cross the track of the storm; the left-hand side is the navigable semicircle,—not very *navigable* in this particular case, we may well believe, with no sea-room to the westward, a fearful N.NE. gale, and a terrific sea. This is a case where every resource of seamanship and navigation may fail to save a ship, as the case of the steamship "Samana" and a dozen other strong vessels, with all on board, bears sad testimony. Let me quote a few lines from a touching report by Captain Drew, of the American ship "Sea Witch" (this vessel's position [illegible] Hurricane from NE.; our position a perilous [illegible] ing heavily and filling the decks with water, an awful gale, the worst we have ever had—how will it end? At 8 P.M., the sun out a moment through the fleecy. Nov. 25 Still blowing a hurricane, with awful squalls of rain, the seventh day of the gale. No sail can be set; the bunnacles [illegible] fast as we can get it. One boat from the north blew our brand-new lower maintopsail away like brown paper. We performed

the critical manœuvre of wearing ship, which saved the vessel: we were foundering." Verily, this was "out of the jaws of death," and probably there were few more sincere thanksgiving services than those on board this vessel on Nov. 28th, 1888, as recorded in her log. One other report may be referred to here, and it is of especial interest. It is from the British steamer [illegible] at [illegible] time the wind was S SE., force 8, and the storm center was moving directly toward her. We learn from Captain Crosby's report that by noon, local time, the wind was strong from S.; at 4.30 P.M., a hard gale from east, increasing until midnight, barometer falling very rapidly. Nov. 28th, very heavy gale from NE., ship heading bow to sea; noon, wind east, barometer 28.04, 3 P.M., wind N NE., [illegible] longitude W., 28.20. This report illustrates the experience of a vessel close to the line of sudden shift of wind from SE. to N NE., and sustains very well the separation lines drawn on the chart, just where there is an absence of data on the chart itself.

Lack of space does not allow of further details, and I must go on to the next plate.

The St. Thomas-Hatteras Hurricane of Sept. 3-12, 1889.

This plate is copied exactly from a Supplement issued with the Pilot Chart for October, 1889 (published Sept. 24th), with only the addition of the tracks of the two storms (as indicated by later data) and the tracks of a few vessels (see small charts dated Sept. 3, 4-5, 10). Considering the early date of publication, the wide expanse of ocean covered by the charts, and their essential accuracy (as indicated by later data) it must be acknowledged, I think, by any one who is at all acquainted with the difficulties incident to this sort of work, that this supplement to the Pilot Chart hit more closely to the truth in this matter than would probably be possible under similar circumstances in one case out of ten. Had later data materially modified conclusions drawn at such an early date, it could not have been a matter of surprise, although this prompt publication would still have served a most valuable purpose in interesting navigators to contribute data likely to help us in establishing the facts. Indeed, the following quotations from the Pilot Chart and Supplement illustrate exactly what was desired, and what was actually accomplished

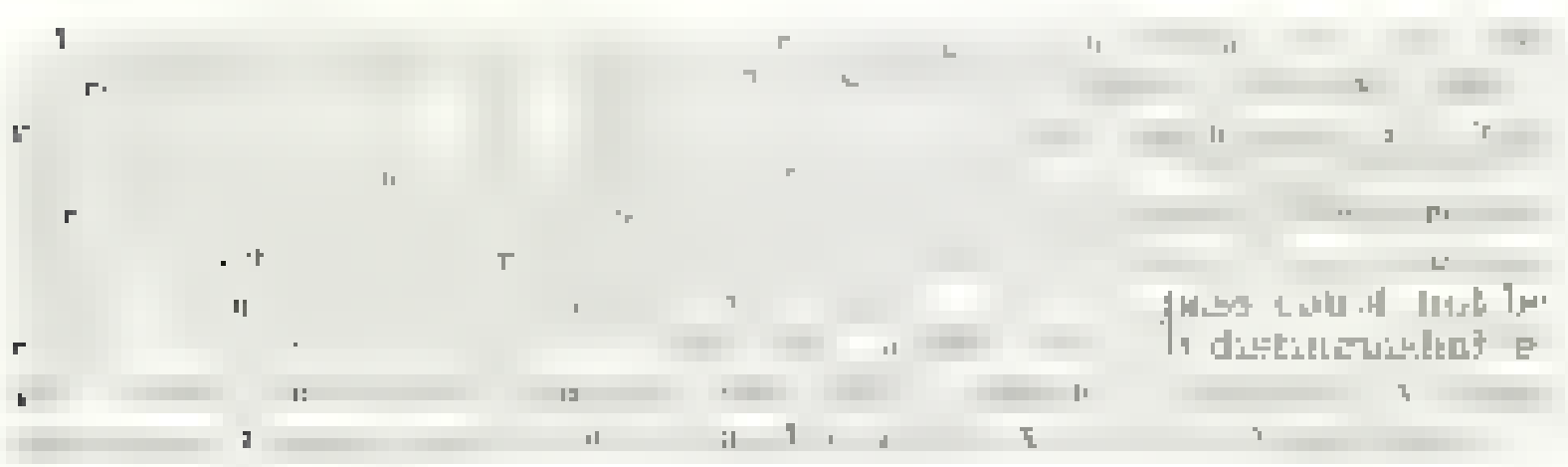
by this publication." "This preliminary publication, issued two weeks after the storm period of August, will illustrate the manner in which the office proposes from masters of vessels in the future to collect and utilize storm reports for the benefit of navigation. It is planned to issue a complete discussion as possible regarding the storms, as soon as to publish a final report, and the present publication will be useful as a guide to such work. Lack of attention in addition to the fact that this preliminary publication is only intended to give a brief outline of the facts as ascertained by data received up to date of publication." Moreover, the name, nationality, and rig of every vessel whose report had been received in time to be used was published, and every statement made in the accompanying text was based on an exhaustive study of all the available

It is interesting to note how slightly the early ones of data now at hand have modified this hastily-prepared history, and how the comparatively few errors of fact which we find should publication, before attempt to cross and other discussions have attracted general attention elsewhere. The

[illegible] of the two storms as plotted on the first chart, shows that it moved more slowly than was supposed, and to travel farther north. The fact is, its very existence was not even suspected till two days before the final draft of the maps was made, and it was only because the German steamship "Bavarian," from Baltimore for Bremen, suffered such damage from the hurricane on Sept. 3 that she put in to St. Thomas for repairs, and there met Mr. M. A. Turner, [illegible] her report by the first steamer to New York. The following is a brief extract from this report, her passage to be at, Sept. 4th: "Fine, but strong, ship lying in trough of sea, labouring heavy and shipping much water. Cargo shifted; jettisoned 100 barrels of flour and 40 tons of coal. Broke steam steering gear and used foot rudder chain. 3 feet of water in the hold, foundation of engines

[illegible] very loose and getting worse. Bore up for St. Thomas."

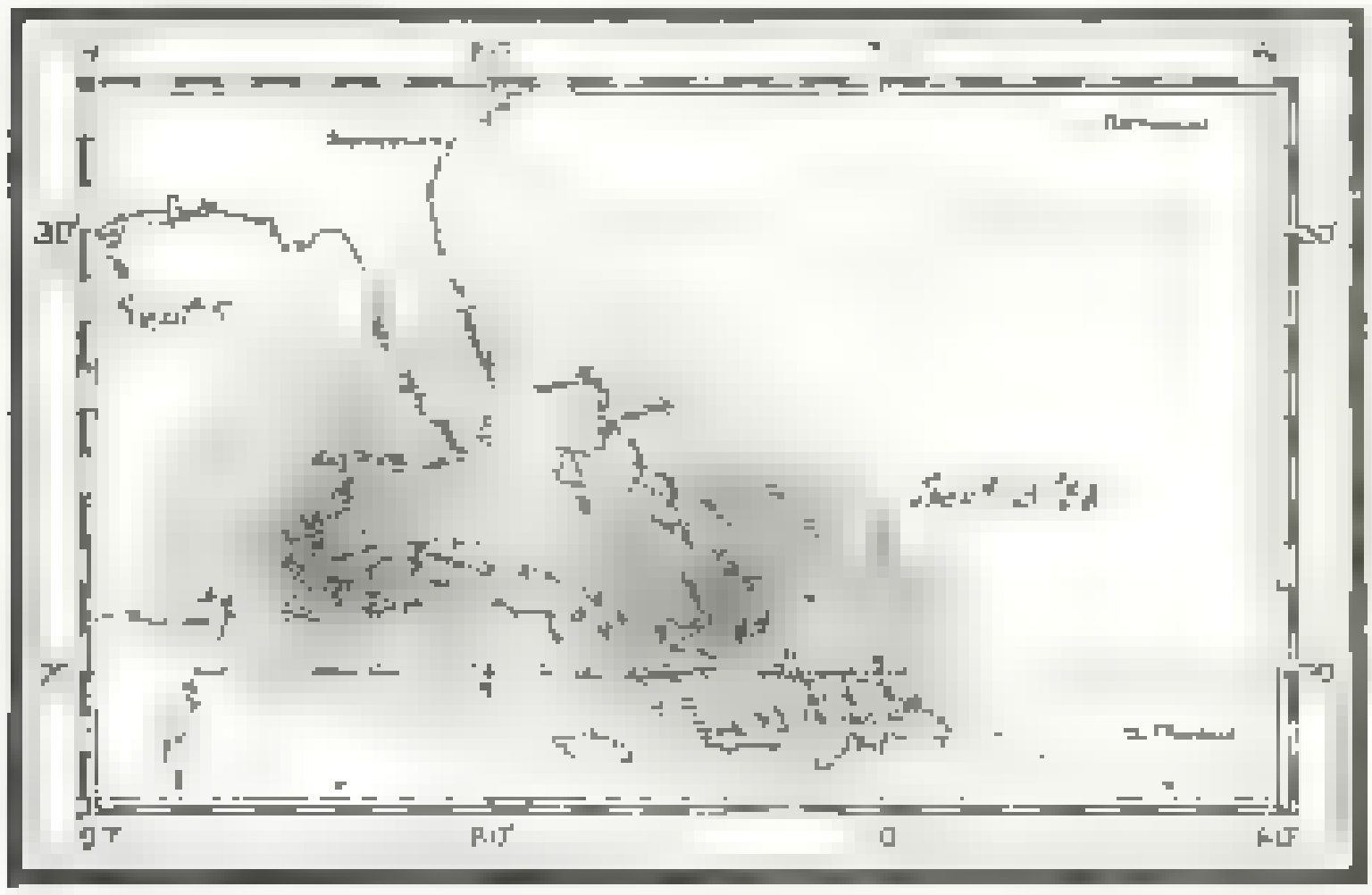
It is impossible, in the space at my disposal, to refer even briefly to the reports of the few vessels whose tracks are plotted on the charts, the staunch steamship "Euramoor," four hours in the heart of the hurricane on Sept. 4th, eleven of her crew of thirty escaping in an open boat, and of these only seven survi-



The importance to navigators of a true appreciation of the law of storms—not the mere theoretical, but a practical rule, not an all-great complicated one if the subject—is now perhaps clearly evident to the reader at any rate that is one of just I have named at, rather than a mere formal statement of generally accepted principles and an abstruse discussion of scholars and geometers.

It will be seen that *the probable direction of the center, as indicated by the direction of the wind at a single station,* is the great point with, as far as the navigator is concerned. There are ships which want and could have a hard-and-fast rule,—an 8-point, a 10-point, 12-point rule—a sheltering to act for all without thought, while every nerve is strained to save the ship's spars, sails, boats, engines, and cargo, from damage or destruction. Under such circumstances, I think that perhaps the safest general plan is to use the old 8-point rule, but *apply it to the low clouds, instead of to the wind.* This is equivalent, generally speaking, to a 16-point

rule applied to the wind. That any such rule, if intended for general application, is only roughly approximate, goes without saying, or ought to go without it, at least. The angle of abrupt changes in different parts of the storm, if varies with the gradient, with the latitude, with different storms, and with various other conditions. For instance, it is known that in rear of a hurricane the wind blows more nearly toward it, and yet there are marked exceptions to this, as illustrated by the hurricane of November 7-8, 1906, [illegible] A good example of these exceptions is to be found in the [illegible]



The Cuban Hurricane of September 29, 1906, as it [illegible] and [illegible]

the 3d and 4th of the great Cuban hurricane of September, 1906, but not overwhelming ones. Such storms may bring calmness, for the sake of clearness. Its severity is sufficiently indicated by the fact that it caused the loss of nearly a thousand lives in Cuba, and destroyed property of the estimated value of $5,000,000 in the single province of Santa Clara. Now take any point on any one of these spiral lines, and observe the bearing of the center in rear of the storm, supposing the Buys Ballot rule to be fairly applicable, and action based upon it might result disastrously.

The [illegible] last paragraph, continued.

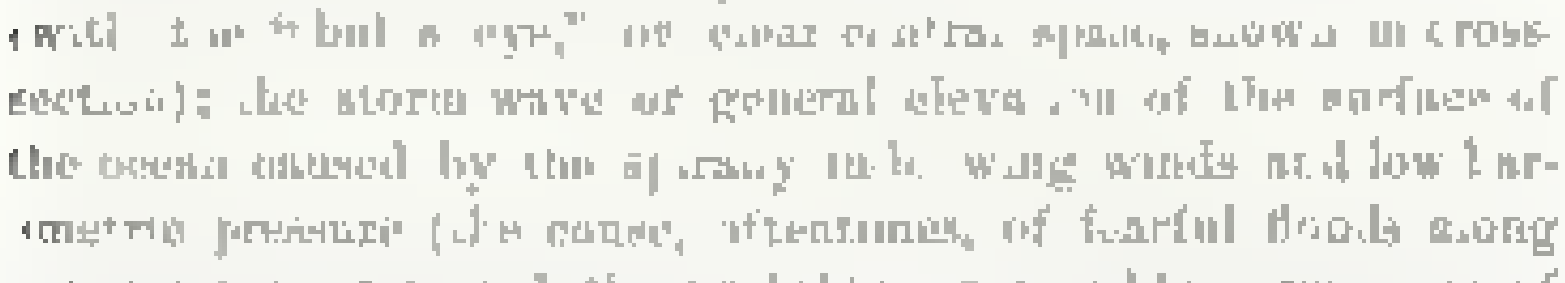
[illegible] IN THE NORTH ATLANTIC.—[illegible] CHART. [illegible] OF [illegible] AND OBSERVATION.

gives a [illegible] more complete illustration of the weather which at-
tributes, with a brief discussion of the application of the
V-point rule. Especial attention is called to the statement made
[illegible] preferring, of course, to hurricanes in the North Atlantic,
but no logical true for the entire Northern Hemisphere, that

"although the V-point rule is usually true when the wind is anywhere
[illegible]
anywhere south of it, it is liable to be a very poor guide to wind or
no from any point in the first or second quadrant."

Now to the fundamental which is applied to the Southern
Hemisphere by the substitution of "to the left" for "to the
right."

"Perhaps the best general rule is that the center bears about eight
points to the right of the direction [illegible]



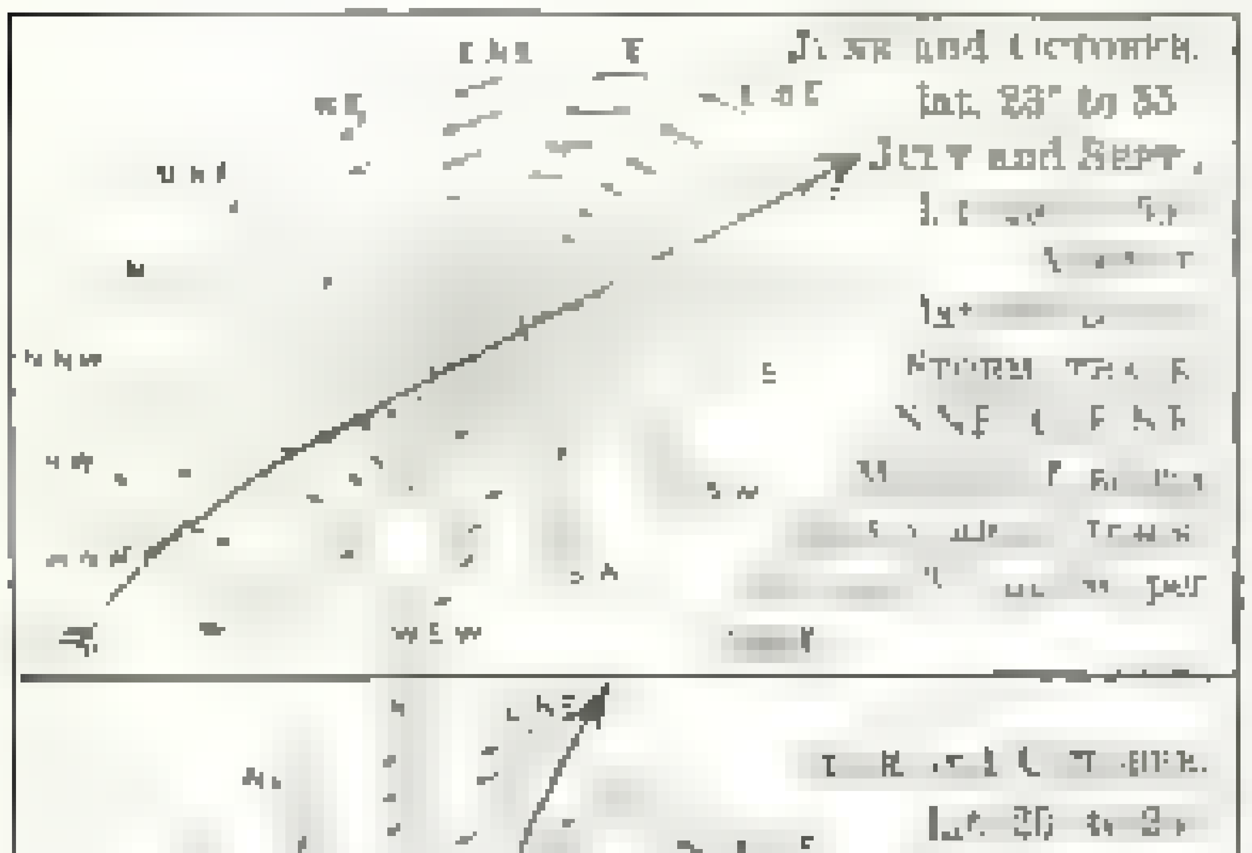
Such diagrams, carefully prepared from complete and reliable
data, are of far greater practical value to navigators than vol-
umes of explanation. They appeal to the eye and the use of
unnecessarily large number of words have been
forgotten.

Finally, let us look for a moment at the sketches that I
have made to give a graphic and I hope not incorrect idea of
the actual formation and the internal structure of a hurri-
cane. In the sketches the vertical scale is of course greatly exaggerated. The first illustration pictures only the great local bank
(with its "bull's eye," or clear central space, shown in cross-
section); the storm wave or general elevation of the surface of
the ocean caused by the already rising winds and low barometric pressure (the cause, attendance, of fearful floods along
sweeping coasts), and the probable, or possible, circulation of
the upper atmosphere over the whole, together with the direct
and reflected rays of a vertical sun as they pour into the equato-
rial calm. The second sketch is to aid a clear mental conception of

WEST INDIAN HURRICANES, AND OTHER NORTH ATLANTIC STORMS

From the Pilot Chart of the North Atlantic Ocean, August, 1889, with Additional Paragraphs

Explanation.—These diagrams are for practical use in West Indian hurricanes. They will also answer for ordinary storms along the transatlantic route. The small arrows fly with the wind [illegible] at the end of [illegible] dotted line, the long arrow on each diagram is the storm track, that is, the probable path of the cyclone through the belt of latitude to which the diagram refers.



Edition of July, [illegible]

Use of the Diagrams.—When a falling barometer, freshening [illegible] a hurricane, select the proper diagram, according to the month and latitude, plot your position upon it [illegible] direction of the wind, and thus ascertain the approximate bearing of the storm center. The probable storm track is indicated by the long arrow. If the wind shift, plot your position [illegible] new wind direction, [illegible] the wind has freshened, and the barometer has fallen. In this way you can readily observe every change of position relative to the storm center and decide what action to take according to the character of your [illegible] in the tropics [illegible] miles [illegible] region of storm [illegible] miles, or even less. You cannot [illegible] distance of the center [illegible] can be obtained from the diagrams with [illegible] degree of probability. There is also [illegible] variation in the direction of motion and the velocity of the storm along its track, but the general tendency is as stated herewith.

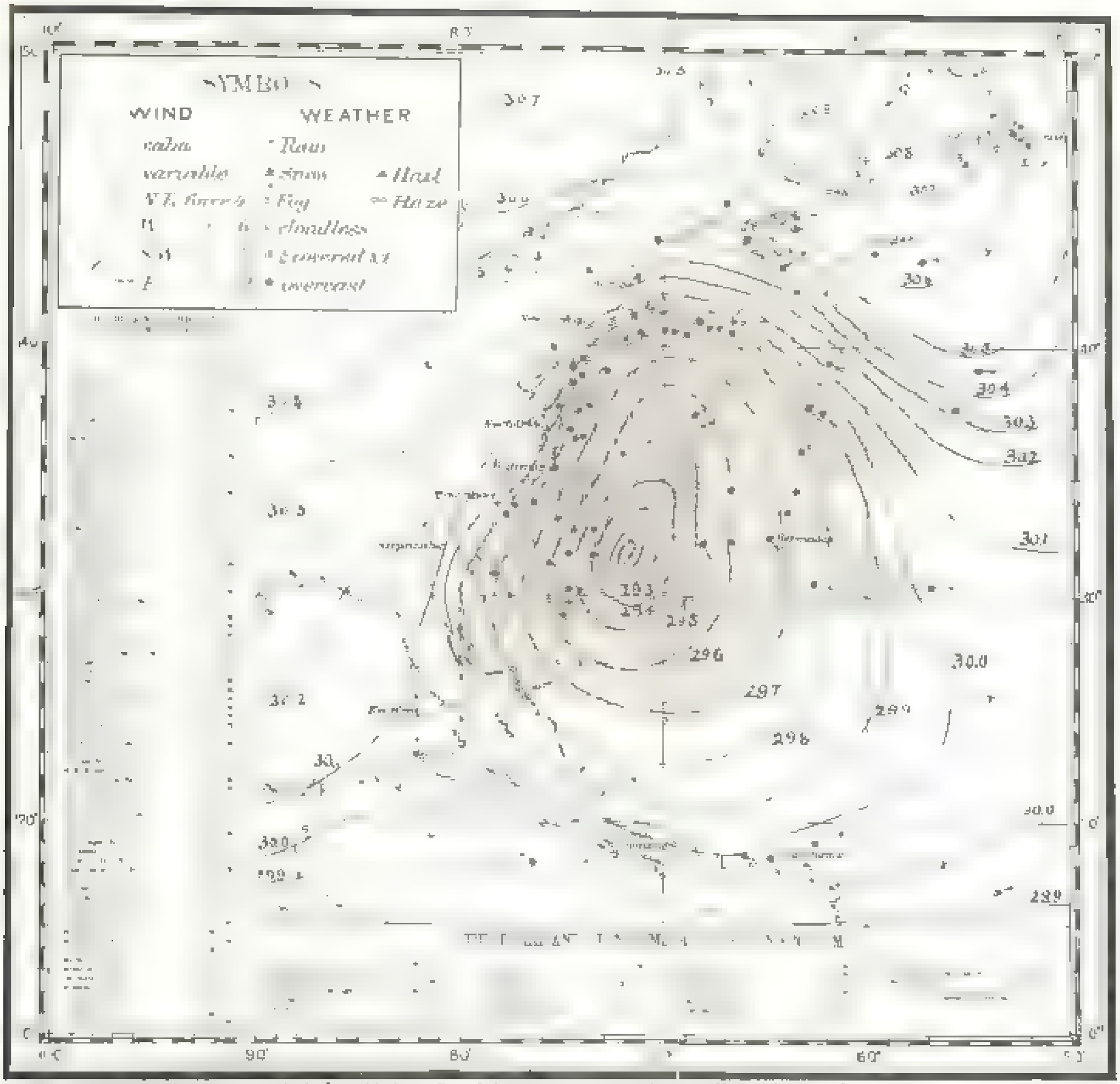
Cyclonic Circulation.—One of the most important indications that an approaching storm is of the greatest violence is [illegible] of the wind, lower and upper clouds, etc. This may be easily explained by remembering that a cyclone of any great intensity is an ascending spiral whirl, with a rotary motion on the Northern Hemisphere against the hands of a watch, as shown on the diagrams. The surface wind, therefore, blows spirally inward and [illegible] except very near the center; the next upper current [illegible] near the center; the next higher current (the [illegible]) is an outward spiral, [illegible] The angle of divergence between [illegible] pass. [illegible] the surface wind [illegible] In rear of a hurricane [illegible] center will [illegible] [illegible] hurricane [illegible]

[illegible] Track [illegible]

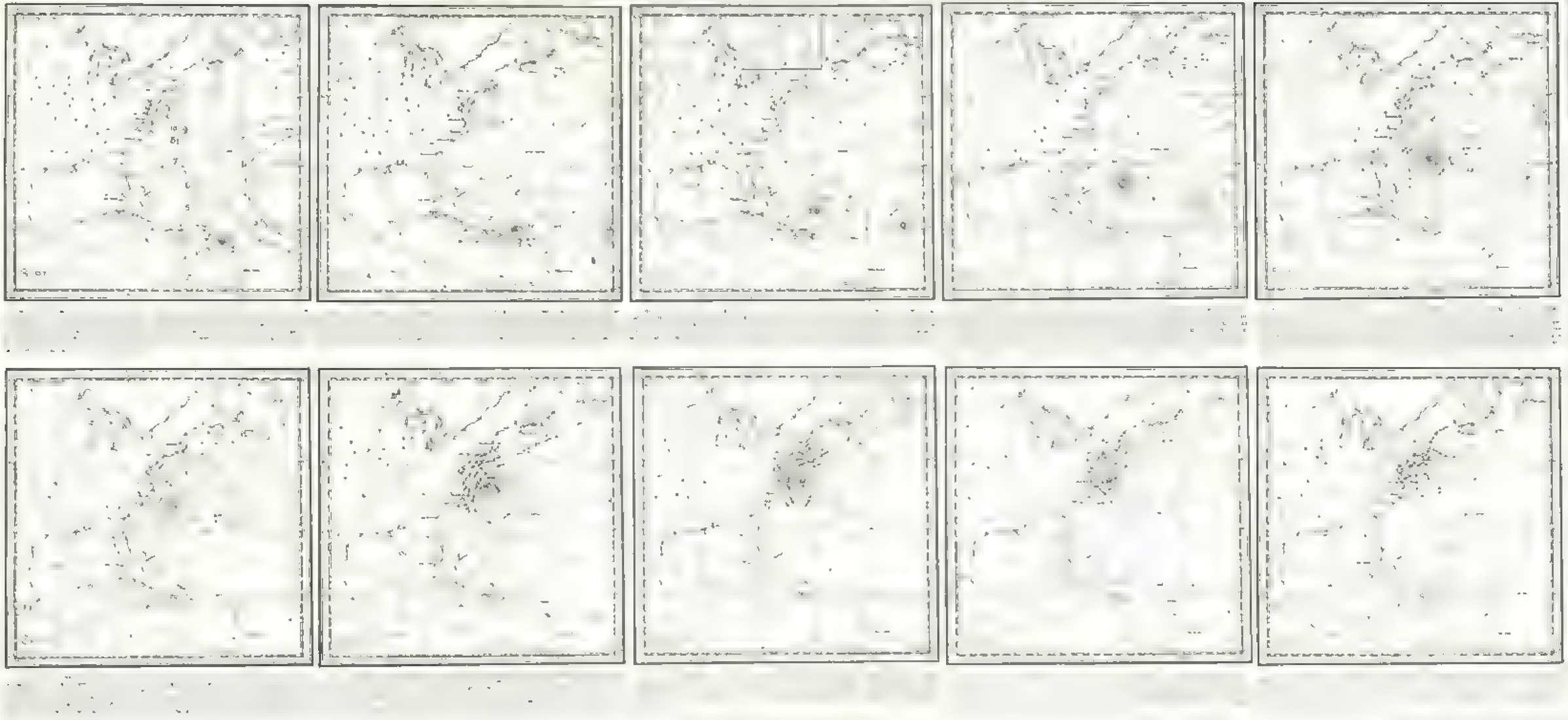
[illegible] the trade- [illegible] track of the storm. By [illegible] to cross the track [illegible] begins to freshen, you are [illegible] the hurricane.

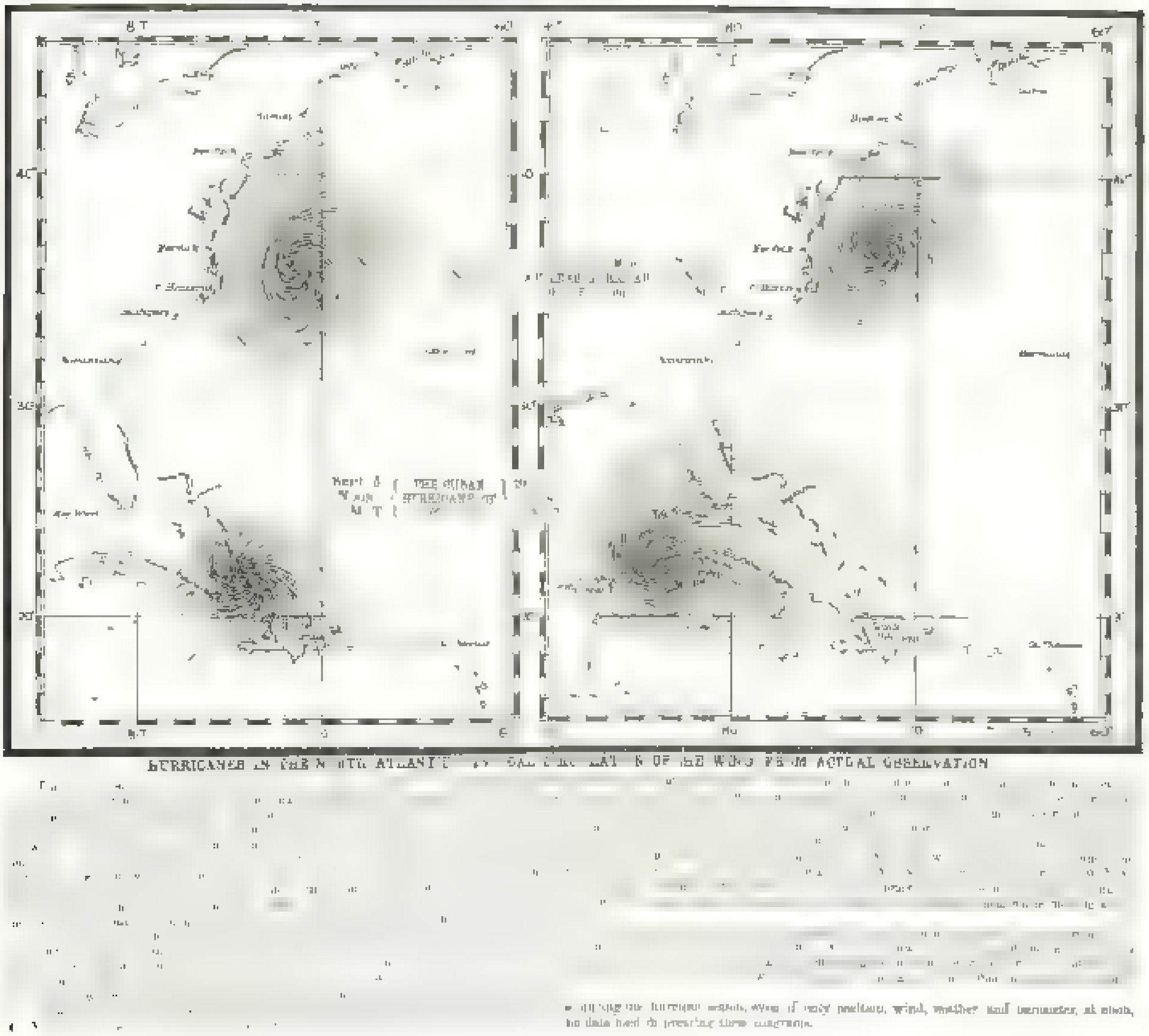
General Information.—[illegible] of the [illegible] Earliest indication [illegible] weather [illegible] from the direction of the [illegible] storm [illegible] light, feathery cirrus clouds, radiating from a point [illegible] horizon [illegible] indicates the bearing of the center. [illegible] signs: falling barometer, [illegible] increasing [illegible] light variable winds, [illegible] bank on the distant horizon; barometer falling more [illegible] winds.

Brief Rules for Action.—If the squalls freshen without any shift of wind [illegible] wind on the starboard quarter and keep [illegible] If the wind shift [illegible] put the [illegible] starboard tack and make as [illegible] until [illegible] If the wind shift [illegible] the starboard quarter [illegible] keep your compass course [illegible] to bring the wind on the port tack. [illegible] always keep the wind on the starboard [illegible] in order to [illegible] out of the storm. Always heave to on the starboard tack. Use oil to prevent heavy seas from breaking on board.


SYMBOLS
WIND
WEATHER
Rain
Hail
Haze
Fog
Thunderstorm
Overcast
Clear
304
303
302
301
300
299
298
297
296
295
294
293

THE ST THOMAS HATTERAS HURRICANE OF SEPTEMBER 3-12 1889





HURRICANES IN THE NORTH ATLANTIC [illegible] DAILY CHART N OF 10° WIDE FROM ACTUAL OBSERVATION

[illegible] the hurricane season, when it rarely reaches, wind, weather and barometer, as shown, no data have to prevailing storm conditions.

trated by the report of the "Schwalbe," quoted above) is of interest to the reader, [illegible] If I have succeeded in this, and thereby given a clearer idea to the general reader or supplied a ferment train of thought to any physicist, I shall feel more than rep[illegible] for the effort.

I have thus attempted little more than to touch upon the practical side of this great question, and this in a popular way, to induce my readers [illegible] how little we know, and how much remains to be learned. The many other [illegible] that might be raised and discussed must be left untouched. Our efforts at the present time must be primarily to observe and gather, and only secondarily to try to collect and publish facts for the meantime to arrange and explain. The causes of these terrific storms are of interest to us as they may help us to prevent or to escape, rather than for the proof of any theory, or the gratification of any pet idea. And if Science will but improve the Law of Storms, as practical men use it for the guidance of their vessels and the safety of the lives and cargoes entrusted to their care, it will be one more victorious proof that theory and practice go hand in hand.

THE IRRIGATION PROBLEM IN MONTANA

By H. M. Wilson

[illegible]

[illegible]

AGRICULTURAL AND MINERAL RESOURCES

It will be advisable now to take a hasty glance at the State of Montana, and see what are her agricultural capabilities and what need exists for irrigation as a factor in their development.

According to the report of the State Auditor for 1900 there were in that year 183,710 horses and mules valued at $1,900,000, and 350,000 cattle valued at $10,000,000; 1,250,000 sheep valued at $2,500,000; 3,740 acres of improved lands, valued inclusive of improvements at $12,300,000; 55,000 town lots valued with improvements at $4,000,000; and included in all kinds of personal and real property in the assessment for the state of $87,000,000.

There were raised in the state during the same year 7,000,000 bushels of wheat on 350,000 acres, an average yield of 20 bushels per acre; 7,000,000 bushels of oats on 85,000 acres, an average yield of over 35 bushels per acre; 600,000 bushels of potatoes on 7,000 acres, or 240 bushels per acre, and 1,000,000 tons of all other vegetables on 450 acres. 325,000 tons of hay were cut, and 1,500 bushels of apples and other fruits were raised, while 6,000,000 pounds of wool were sheared.

The gross amount of the gold, silver, lead, and copper mines of the state in 1900 was $60,000,000, the largest amount of the product of the precious metals in any state or territory in the Union, and the most valuable product being 100,000 tons of coal.

The wool product for the present year, 1901, exceeded in amount that of any other State west of the Missouri River, and its quality was such that it brought a higher price per pound than that of any other western State, the price paid in Boston being from 18 to 19 cents per pound against 16 to 17 cents in Montana.

There are appearing in the newspapers from time to time articles descriptive of the agricultural possibilities of the Flathead Indian Reservation, from which it might be seen that Montana will contribute as

Silver	$ "	"	$ "
Copper	"	"	"
Lead	"	"	"
Total	$ "	$ "	$ "

Since [illegible] Montana has only commenced to be developed, as the principal [illegible] of its great mineral and agricultural resources

the total value of the precious metals produced, but also in the value of the silver and copper products separately, and is now surpassed by a uniform increase in the production of gold.

While Montana produces large quantities of vegetables and grain, the supply is rarely sufficient and much live stock formerly had to be fed from the eastern States to tide the range stock during the winter.

TOPOGRAPHY.

The topography of Montana is very different from what is generally supposed by those who are not familiar with it, and this erroneous impression is largely due to the fact that the country is very mountainous in the old settled and better known portion of the State, which lies west and southwest of the Missouri and Yellowstone rivers. This region was first inhabited by those pioneers of western civilization, the prospector and miner, and in consequence of this and of the wide fame of the Yellowstone National Park, the generally prevalent notions of the topography and resources of the State are of forests and mountains with grazing and fish, and suggest impressions entirely at variance with the broad plains and fertile valleys.

On the east many large areas extend over various parts of the State, on which large towns, two of which, Butte and Helena, have each about 20,000 inhabitants, while only a small fourth of the area of the State is yet occupied for farming, and at least two thirds of it is below 6,000 feet.

The mountainous district of the State, which occupies but little more than one third of its total area, is on the southwestern portion, where two ranges unite in the Rocky Mountains proper, which here form a broad belt from Wyoming and Idaho northward, and the waters of the Missouri flow from the eastern slope of the Mountains, while on the western slope

It is in these great mountain ranges that the Clark's Fork and Kootenai Rivers, two of the great principal tributaries of the Columbia River system, have their sources, and southwestern part of the State [illegible] Rivers flow to the west to the Arctic Ocean, while the

great Missouri and one of its principal branches, the Yellowstone River, rise in three mountains and after flowing northward nearly to the border turn and flow eastward and join the Missouri on its way to the Atlantic.

The highest mountains in Montana are in Park, Gallatin, Madison and Lewis and Clarke counties, in which is found the furthest upward extension of the Missouri, the Beaverhead and Big Hole rivers, which form the Jefferson river, and the extreme head of the Yellowstone and it was here that those intrepid explorers, Lewis and Clarke, first crossed the Continental divide in the most direct line in advance of any of the later lines of the Northern Pacific.

In these mountains a few of the highest peaks reach an elevation of 11,000 feet, and from under the main range of the Rockies head off to the north and east, with occasional ragged ridges and peaks, with extensive belts of timber and much of the headwaters of the Beaverhead River, most prominently fading off in elevation until near the Jefferson are the highest peaks are less than 7,000 feet above the sea.

From this point on to the southeast corner of the state, branches of the Rockies, called on the Northern Pacific maps the Belt Mountains, have an elevation of 8,000 feet in northern Missoula county where the Northern Pacific river leaves the State, it runs across the foot of the range.

East of Madison and Jefferson counties, and along the southern border of the State, are a succession of mountain ranges, often 9,000 feet and sometimes 10,000 feet in elevation, which rather generally run northeast and southwest and fall off near the eastern line of the State in a comparatively broad, and nearly level high prairie, or as it is locally called "bench land," which continues to fall slowly as the state slopes.

Do not suppose that these great ranges of mountains are wild and untamed for much as they are rugged, they are nearly great mountain meadows, and between ridge and top of them are all or nearly all the valleys of considerable, many miles in length, separated by broad, level and very fertile valleys, everywhere cleared and cultivated by the hand of man, with fields of cattle, horses and sheep grazing on the hillsides.

Even those of the most extensive mountains may travel many miles on horseback at the top of their ridges without finding so much as the

Area and Kinds of Lands.

The total area of Montana is 146,080 square miles, or 93,491,200 acres. Of this vast empire 31,575,000 acres or about one-third of the whole is agricultural land, while of this 18,157,000 acres or a little less than one-fifth of the entire area is irrigable land, so classified not only because it will, if provided with water, raise profitable crops, but also because, in my opinion, water can with proper management be provided for it.

Of the total area of the State only about 1,200,000 acres or less than one-sixteenth of the irrigable area may be easily cultivated, by this I do not mean that this whole amount is now reclaimed, but that it may with the means available to be employed by private parties with limited capital, be readily brought under cultivation by the same methods by which most of the lands in Montana are now irrigated.

The amount of land actually under cultivation, according to the assessment of 1888, was 348,[illegible] acres, and this should probably be increased by about one-half, since the farmers doubtless greatly underestimated the amount of their cultivated areas to the assessor; perhaps then, 500,000 acres under cultivation would be nearer the truth.

It is estimated that three-fourths of the remaining 75,000,000 acres not classed above as irrigable, or say 55,000,000 acres, which is nearly two-thirds of the total area of the State, will, with the increased facilities for watering live stock and for domestic use offered by the highest state of irrigation development, become valuable as grazing land, since it is naturally covered with an abundant growth of bunch grass, and only needs better facilities for watering and for the establishment of home farms, to cause it to be entirely occupied for grazing purposes.

Nearly, or quite all, of the lands above classified as agricultural and pasture lands, are now covered with an abundant growth of bunch grass, occasional patches of sage brush or prickly [illegible] and devoid of any trees other than patches of willows and [illegible] cottonwoods along the streams, or a few isolated clumps of [illegible] pines and junipers on the highest lands.

Nearly [illegible] per cent of the [illegible] of timber lands and are situated [illegible] the mountains, though west of the Continental Divide the valleys and flat benches also are sometimes covered with timber.

The remaining 10,000,000 acres may be classed as barren and rugged mountain peaks and snow-capped barren "bad lands" near the southeastern corner of the State, and the broken and rough wet banks of rivers, "coulees," etc.

It is in these more fertile mountain regions that the great gold, silver and copper deposits are found.

CLIMATE.

The climate of Montana is for the most part moderate and agreeable, that is generally enjoyed, the spring and fall months in the valleys, which are the principal and oldest and cultivated portions, being delightfully mild and pleasant, with frost generally only at night, though I have had the 1st of May and 1st of October.

The accompanying table shows the dates of the first and last killing frosts at Helena, and the mean monthly temperature at Helena, which place is considered as a typical station, as situated about 4,000 feet above the valley, which extends over a period of ten years, from 1887 to 1896, inclusive, with few exceptions, it appears that the earliest killing frost occurred on September 6th, 1891, and the latest killing frost on May 31, 1895, but these were very exceptional years, the average dates for the whole period being September 20th and April 27th. The most severe temperature during the same period occurred on July, 1888, and was 102 degrees above zero, while the most severe cold was 32 degrees below zero; and the average annual temperature for the ten years was 44 degrees. The lowest temperature for the same period was 4 degrees, occurring in February, 1893, and the average minimum for ten years was 14 degrees. Severe changes of temperature are one more pleasant than severe, except in local areas in the higher mountains, where snowfalls from a mild storm have occurred, though rarely, killing grain and cattle in the valleys even in June and July.

The following table of temperatures at Helena, Montana, gives the mean monthly, annual and seasonal temperature for a period of ten years, from 1887 to 1896, inclusive, as taken from the records of the Signal Service Station at that place:

	Mean Monthly Temperature.											
	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1887	20.6	23.2	34.2	43.2	52.2	59.2	64.2	61.2	50.2	41.2	29.2	23.2
1888	20.6	23.2	34.2	43.2	52.2	59.2	64.2	61.2	50.2	41.2	29.2	23.2
1889	20.6	23.2	34.2	43.2	52.2	59.2	64.2	61.2	50.2	41.2	29.2	23.2
1890	20.6	23.2	34.2	43.2	52.2	59.2	64.2	61.2	50.2	41.2	29.2	23.2
1891	20.6	23.2	34.2	43.2	52.2	59.2	64.2	61.2	50.2	41.2	29.2	23.2
1892	20.6	23.2	34.2	43.2	52.2	59.2	64.2	61.2	50.2	41.2	29.2	23.2
1893	20.6	23.2	34.2	43.2	52.2	59.2	64.2	61.2	50.2	41.2	29.2	23.2
1894	20.6	23.2	34.2	43.2	52.2	59.2	64.2	61.2	50.2	41.2	29.2	23.2
1895	20.6	23.2	34.2	43.2	52.2	59.2	64.2	61.2	50.2	41.2	29.2	23.2
1896	20.6	23.2	34.2	43.2	52.2	59.2	64.2	61.2	50.2	41.2	29.2	23.2

The following table of temperatures at Helena, Montana, gives the mean monthly, annual and seasonal temperature for a period of ten years, from 1887 to 1896, inclusive, as taken from the records of the Signal Service Station at that place:

	Mean Monthly Temperature.											
	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1887	20.6	23.2	34.2	43.2	52.2	59.2	64.2	61.2	50.2	41.2	29.2	23.2
1888	20.6	23.2	34.2	43.2	52.2	59.2	64.2	61.2	50.2	41.2	29.2	23.2
1889	20.6	23.2	34.2	43.2	52.2	59.2	64.2	61.2	50.2	41.2	29.2	23.2
1890	20.6	23.2	34.2	43.2	52.2	59.2	64.2	61.2	50.2	41.2	29.2	23.2
1891	20.6	23.2	34.2	43.2	52.2	59.2	64.2	61.2	50.2	41.2	29.2	23.2
1892	20.6	23.2	34.2	43.2	52.2	59.2	64.2	61.2	50.2	41.2	29.2	23.2
1893	20.6	23.2	34.2	43.2	52.2	59.2	64.2	61.2	50.2	41.2	29.2	23.2
1894	20.6	23.2	34.2	43.2	52.2	59.2	64.2	61.2	50.2	41.2	29.2	23.2
1895	20.6	23.2	34.2	43.2	52.2	59.2	64.2	61.2	50.2	41.2	29.2	23.2
1896	20.6	23.2	34.2	43.2	52.2	59.2	64.2	61.2	50.2	41.2	29.2	23.2

Annual Climatological Means

The temperature and precipitation values are means for the period 1931–1960. At this and other locations, temperature and precipitation are recorded daily. Unless otherwise noted, the means are based on the data for each day in the month. Thus, if data are missing for 5 days, the monthly mean is the sum of the available data divided by 25.

	Temperature (°F)				Precipitation			
	Daily Maximum	Daily Minimum	Monthly Mean	Record Mean	Mean Total	Greatest Total	Least Total	Record Mean
January	36.8	20.0	28.4	31.8	1.38	3.10	0.21	1.52
February	38.4	21.8	30.1	33.6	1.22	2.85	0.30	1.41
March	50.4	31.4	40.9	43.1	1.74	3.62	0.55	1.88
April	62.0	41.6	51.8	53.4	2.31	4.07	0.88	2.20
May	73.4	51.4	62.4	64.0	3.05	5.41	1.12	3.02
June	82.1	60.7	71.4	73.2	3.62	6.18	1.40	3.55
July	86.3	66.8	76.6	78.1	3.88	6.74	1.61	3.80
August	84.1	64.2	74.2	76.0	3.41	5.96	1.33	3.34
September	78.6	56.4	67.5	69.2	2.66	4.88	0.97	2.61
October	66.2	44.7	55.5	57.3	2.04	3.71	0.74	1.99
November	52.8	34.0	43.4	45.1	1.61	3.05	0.49	1.58
December	41.5	25.3	33.4	35.0	1.47	2.78	0.33	1.44
Mean / Annual	63.4	43.0	53.2	54.8	28.37	46.35	10.13	27.74

Annual climatological means. Monthly and annual means of daily maximum and minimum temperature and precipitation, with record means and extremes, for the period 1931–1960.

dryness of the atmosphere and the absence of very high winds in the mountain valleys. The more exposed plains to the north are subject to the frequent and agreeable visits of the famous "Chinook" winds, which blow from the west, and under whose influence heavy falls of snow disappear in a single day.

The following table shows the mean annual rain fall at various Signal Service stations in Montana, and from these it will be seen that during a period of ten years the [illegible] entire State has only been [illegible] has occurred during 1886 and was but 13.52 inches [illegible] precipitation for the period was [illegible]

Mean Precipitation in Montana during Growing Season

Growing season of '8[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.65	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
" " " '8[illegible]	[illegible]	7.[illegible]	5.[illegible]	9.90	5.67	7.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
" " " '82	8.4[illegible]	1.20	5.[illegible]	[illegible]	3.64	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
" " " '84	17.[illegible]	[illegible]	6.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
" " " '85	[illegible]	[illegible]	[illegible]	6.77	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
" " " '8[illegible]	[illegible]	[illegible]	9.30	4.29	3.28	4.07	10.64	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
" " " '89	5.18	[illegible]	3.49	3.20	2.27	2.[illegible]0	[illegible]	[illegible]	1.[illegible]	2.93	1.[illegible]	2.[illegible]	[illegible]	[illegible]

Growing season, May 15 to August 15.

Annual Rainfall in Montana, 1880–1888

	1880	1881	1882	1883	1884	1885	1886	1887	1888
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ft. Buford, N. D.	23.25	10.90	12.78	[illegible]	7.87	13.76	9.24	15.43	14.70
F[illegible]	[illegible]05	[illegible]88	[illegible]		16.40	9.34	13.25	14.16	17.00
F[illegible]	[illegible]64	[illegible]1	[illegible]						
[illegible]		10.84	16.32		10.18	13.90	12.63	14.[illegible]5	10.14
[illegible]				9.29	[illegible]	13.86	15.44	26.00	25.70
[illegible]		10.66	9.24						
[illegible]						[illegible]25	11.93	7.4[illegible]	15.5[illegible]
[illegible]			8.77	14.2[illegible]	19.64	18.84	13.50		
[illegible]	[illegible]		[illegible]	15.72	29.02	32.83			
Virginia [illegible]	[illegible]								
[illegible]	30.90	10.0[illegible]	9.63	16.69	15.78	9.41	12.59	15.67	13.45

Moreover, from the first table, showing the average monthly precipitation at the Helena station, it will be seen that but 4.44 inches fall during May, June, July and August, the time when the crops require the greatest moisture.

[illegible] for stations situated in different parts of the State during August, September and October, it appears that the total average evaporation for the three months will be 10 inches, and from the best information obtainable it appears that the total annual evaporation in the state, that is to say, the surface of the water in a lake or reservoir will be lowered by evaporation 3 feet or more.

How Montana is an Agricultural State

It has been stated by Major J. W. Powell, that in a general way the area between the limit of rainfall sufficient for agriculture and practicable irrigation is that most necessary for the cultivation of crops, as from it the greatest profits per acre may be obtained. This of course depends largely on the distribution of the rainfall, the proportion falling during the growing season, the humidity of the atmosphere, the character of the soil.

The average annual precipitation at Miles City is 14.82 inches, while the total average precipitation during the growing season is but 8.31 inches; from these data it will be seen that [illegible] from the Miles City district

This state of affairs does not by any means imply that the farmer will not be able to undertake to raise any kind of crops without the aid of irrigation, since experience has taught them all, that, though there may occur two or three successive seasons in which but few good crops will be raised, still the years when crops depend entirely upon rainfall will be the majority by far, and the frequent occurrence of a number of farming without irrigation is very hazardous and improbable.

The soil along the stream bottoms at an elevation above their beds is usually a heavy, black, clayey loam, and though rich and fertile is soon clogged by water, and due to drying, cakes on the surface, killing the young plants. On account the irrigator seldom wets these bottom lands until after the crop has acquired a healthy growth, preferring to trust to the early rains

[illegible] sage sprouts above the surface, rather than run the risk of its crusting and thus preventing them from breaking through.

These bottom lands thought ready for irrigating, are usually two to [illegible] years not cultivated, because of the greater ease and cheapness of supplying them with water. From two to three tons of hay are from 35 to 50 bushels of grain per acre are raised even on these inferior soils.

The best, and by far the more abundant agricultural lands, are the "bench lands," these are situated high above the stream beds and the soil is usually a warm open, rich, sandy loam, several feet in depth and usually underlain by a deep bed of gravel. Though irrigating, thus soil at first requires more water, it will, owing to its excellent natural drainage, last for all time and will not after long use require water for cultivation.

It is these benches lands which will be rendered irrigable by government and and surveys, though to develop them will require large amounts of capital; but, they are so extensive in area that the work can generally be conducted on a grand and economical scale.

Duty of Water

From the meagre information now obtainable it is probable that a average each and for the staple hay, grain and vegetable crops in Montana, about one cubic foot of water per second flowing during the irrigating season, will be sufficient for 100 acres; this unit is known as the "duty of water."

The irrigating season lasts about three months. While the crops are maturing, during part of May, June and July, they will receive two or three waterings, and in early September the hay lands are again watered in order to start the growth of grass before the frosts.

In case all the surplus water of a given stream is stored, the supply of that stream will be increased by the amount of water now allowed to waste during the remaining nine months, and as a portion of this time is the flood period, owing to the melting of the snows in the mountains and to the spring rains, this storage water will increase the duty of the stream at least five-fold; that is, five times as many acres may be irrigated by the stream as at present, provided that storage capacity can be found for all of the water [illegible]

In considering the duty of a stream it must be remembered that there is a great loss of water by seepage through the sides of a canal and evaporation from its surface, between the headworks and the irrigated lands; this loss may amount to from 25 to 35 per cent., according to climate, soil, and the length and cross-section of the canal.

Present State of Irrigation: Practices and Laws

The [illegible] stages of irrigation development are better illustrated [illegible] Montana than in any other State in the Union.

There irrigation practice and laws are exceedingly crude and remain so chiefly because of the abundance of water, and the [illegible] facility with which it can be diverted to the land; as a consequence of this latter fact the laws were framed in the most liberal spirit, [illegible] right of eminent domain, acknowledging the right of priority in appropriating the waters, and further stating that any person having a ditch leading to irrigable lands may use the waters of the territory for irrigation.

The latest law, framed in 1885, is a very slight improvement; it requires persons appropriating water to post the legal notice in a conspicuous place; to file with the county recorder a notice of appropriation, with names and proper description of stream, etc., and that work must be commenced within forty days of the posting of the notice and be prosecuted with diligence until completion.

Persons who have heretofore acquired title to the use of water, may within six months from the passage of this law file a statement of the above facts in the office of the recorder, but failure to do this shall not forfeit his rights.

Provision is made for the measurement of water, using that very uncertain and elastic unit, the miner's inch, and defining the same.

The difficulties arising under these laws will be appreciated when I state that it is impossible to construct a rating flume that will measure the number of inches of water flowing in a large stream, by the method provided in the law.

Then, because previous appropriators are not compelled to record the amount of water appropriated, and those acquiring titles under the first law invariably claim much more water than they need, in fact often appropriate and even record more water than there is flowing in the stream. This is owing to the fact that

they were not at first compelled to construct their works "with due diligence and completeness," nor to make ditches of capacities capable of carrying the volumes claimed and above all because there is no officer having the power to measure the quantities of water diverted or to see that the works are proceeded with due diligence. Endless and unsatisfactory litigation results, hastened by the occupation of lands lower down on some stream which in a very dry season may not flow sufficient water for all the appropriators who have legitimate titles, whereupon the latter settlers who have recorded their appropriations claim the water, while those who diverted water before the passage of the last law claim the right to it, though unrecorded, and as a consequence the case is carried to the courts, often with unjust and always with expensive results.

During the past unusually dry season these conditions led to much bitter litigation, often to bloodshed, and equally often to final ruin owing to the supply of water being insufficient to mature the crops planted.

Water being very scarce in the smaller mountain valleys has led to great wastefulness in its use, the irrigator after applying what water he can needed, instead of turning it back into the stream for the use of settlers lower down, generally turns his head-gate on the open ditch and allows the water to run to waste. Then wasteful methods of applying the water to the crops are employed, and owing to the cheap and hasty construction of a vast number of small ditches the loss by seepage is very great; it has been estimated that there is on an average a ditch for every 640 acres of land cultivated, making a total of about 2000 irrigating ditches in the State.

In the last two years there has been a marked increase in the interest taken in irrigation enterprises, and though this has resulted in the formation of several large companies, which intend to take water by large and expensive canals to sections now cultivated, yet in these cases are universally seen the same crude methods employed as first beginners, without the aid and advice of experienced engineers. Large canals are being constructed at great cost, capable of carrying many times the amount of water flowing in the streams at present, whereas a much smaller and less expensive one would have carried the entire water supply. Again, small canals have been constructed to carry small volumes of water very long distances, often 60 to 80 miles, while in

really owing to the great percentage of loss by seepage and evaporation, little or none of the water entering at the headgates will ever reach the irrigable lands.

Such ill advised projects are to be even more deplored than the smaller operations before spoken of, since the certain loss of capitalists from investing in even well planned irrigation projects, and will retard the construction of valuable and necessary works.

Possible Irrigation Enterprises.

During the past season the author made an extensive though hurried reconnoissance of Montana, in the progress of which he rode on horseback 1,200 miles and traveled 3,000 miles by rail, examining with some degree of detail all of the central counties and making a few hasty trips into Chateau, Dawson and Custer Counties. In the course of this reconnoissance the sites for sixty storage reservoirs, having a combined storage capacity of about 3,500,000 acre feet were carefully examined, and lines of the great irrigating canals approximately decided on. It may be well to state here that an acre-foot of water is a very convenient unit of measure adopted by the U. S. Geological Survey in speaking of the contents of large reservoirs, and refers to a body of water one acre in superficial area and one foot in depth.

In every case these proposed reservoirs are so situated, that their storage water will be convenient to large bodies of irrigable land, which, without some such provision for water supply must forever remain uncultivated, but which with irrigation from these reservoirs will ultimately become thickly inhabited and very productive regions. The same statements apply to the canals projected, though of course detailed surveys may prove the impracticability of some of these works as first outlined.

Mention will be made of a few of the more important of these projects; those which appear most likely to prove financial suc-

cess.

North of the Yellowstone and between it and the Musselshell [illegible] a few easy courses, by escapage in time of melting snow or heavy spring storms, and then raging torrents for a period of a few days or hours. The bench land between the coulees is flat topped and has a regular and gentle slope to the eastward,

[illegible] about six feet per mile, a little more rapidly north of [illegible] eral elevation of this branch above the Yellowstone River varies from one foot north of Stewart, to 400 feet north of Miles City, and includes about 11,000,000 acres, of which at least 8,250,000 acres are of the best quality for agricultural purposes and readily accessible by the great canal. In all this vast area there is not even sufficient water for the few horses and cattle which range on it, and they are compelled to congregate near the occasional pools and springs scattered at long intervals over it.

From numerous examinations made hastily with aneroid and hand-level, it seems likely that a great canal can be taken from the Yellowstone, somewhere in the neighborhood of Livingston or lower down the river, and led upon the summit of the bench with a diversion line not over 100 miles in length. Taken out at Livingston the canal would encounter no difficult construction, and would chiefly consist in extra excavation with very little rock work. It would require a few flumes and [illegible] the larger side streams, such as the Little and Big Timber and Sweet Grass Creeks. It would reach the summit somewhere north of Norris at an altitude of about 4,400 feet and thence could be conducted with easy grades northeastward, with descending lines to lower grade.

The water flowing in the Yellowstone River at Livingston during the irrigating season this year averages 4,000 cubic feet per second, which, with an allowance of thirty per cent. for loss by seepage and evaporation in the canal, would carry about 1,800 second feet at the point of diversion or a sufficient to irrigate 180,000 acres.

The average normal discharge from Yellowstone Lake is 700 second feet, and a dam about 8 or 9 feet high and less than ten feet long, constructed below the outlet of the lake, would store the outflow from October to May, [illegible] total including flood discharges of at least 600,000 acre feet, an amount which, allowing for loss by evaporation in the lake, and by seepage and evaporation in the canal, would irrigate [illegible] acres, in addition to the 180,000 acres previously mentioned. Besides this volume probably half as much more can be readily stored on the Lamar and Gardner Rivers, and the other branches of the Yellowstone which join it above Livingston, bringing the total area of reclaimed land to nearly 1,000,000 acres.

There are many similar and even better opportunities for irrigation development, such as the construction of a canal from the Yellowstone River near Bozeman. This canal would require no expensive diversion dam, as its waters would become immediately available at the headworks, and by appropriating but 5 00 second feet of water flowing in the river, would reclaim at a minimum cost 50,000 acres, or twice the amount of land now cultivated there. Storage on the Upper Madison River would greatly increase the amount of reclaimed land.

Storage reservoirs can be easily constructed on the headwaters of the Beaver Head River, whereby at least 100,000 acres could be added to the 25,000 acres now under cultivation in the Beaver Head Valley near Dillon.

A canal requiring no diversion dam can be taken out on the east side of the Missouri River near Toston, which will irrigate all of the good land in the Missouri Valley, at least 100,000 acres. This canal would require no headgates and expenditure in removing the various side streams such as Deep and Duck Creeks, and Confederate Gulch.

Detailed surveys have been made during the past summer on the Sun River which indicate that storage will add some 200,000 acre feet to the amount of water in that stream now available for irrigation. There are at least 140,000 acres of good agricultural land between the Dearborn, Sun, and Teton Rivers, which must forever remain barren of cultivated products unless provided with water by means of storage on these streams, and the surveys above alluded to indicate that by this means 400,000 acres of this land can be reclaimed by the Sun River alone.

Mention might be made to many more similar projects, such as the construction of a single canal from the Missouri River to irrigate Chestnut Valley, south of Great Falls, whereby 120,000 acres would be reclaimed, or one from the Upper Madison River whereby 200,000 acres of the Madison Valley might receive water, but the foregoing will suffice to show the possibilities of irrigation development in Montana.

It would be doing the resources of a great and vast area of Montana injustice if reference were not made to the Milk River country, the great Indian reservations of 17,600,000 acres in the northern part of the State which has recently been open to settlement. This region has not been examined by the author, but from conversations with a number of the well-informed inhabi-

tants it appear that the soil is very fertile, and that during average moist years excellent crops can be raised there without irrigation. This last statement, however, should not be too readily accepted. It is probable that some storage water may be retained in the hills along the British line, though its development will doubtless involve international questions.

A Glance at the Future.

This interesting subject cannot be passed by without a little castle building, and accordingly an attempt will be made to show what the future of Montana may owe to irrigation.

It has just been shown how and where 1,750,000 acres may be added to the area at present under cultivation; many times this amount, however, can be reclaimed. Settled as closely as a large irrigated district would naturally be, these 1,750,000 acres will be increased by about 15 per cent, or 262,500 acres, the area which will be occupied by roads, buildings, and towns; that is to say over 2,000,000 acres will be rendered capable of sustaining the highest degree of settlement, though in reality this amount will be much greater since a large portion of the land will not be directly irrigated, since it will indirectly receive sufficient moisture from the neighboring fields to render it serviceable for pasturage.

It has been claimed by various authorities that a homestead of forty acres is abundant for the support of a family, assuming this estimate to be correct, then 2,000,000 acres will support 50,000 families; at five persons each this would give a farm population of 250,000. This number of farm workers would require a town and village population of one and one-half more, or our 2,000,000 acres would add in all 375,000 people to the State.

On the same basis the 18,000,000 acres which have been classified as irrigable land, (and this estimate is below that of the Montana Society of civil engineers and other authorities), would support 3,120,000 inhabitants.